GENERAL LEE'S FAMOUS RAILWAY MONITOR.

Ordnance Department Document No. 2034

RAILWAY ARTILLERY

A REPORT ON THE CHARACTERISTICS, SCOPE OF UTILITY, ETC. OF RAILWAY ARTILLERY

IN TWO VOLUMES

VOLUME I

WASHINGTON
GOVERNMENT PRINTING OFFICE
1921

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ORDNANCE,
March 16, 1920.

This work on Railway Artillery is a Report on the Characteristics, Scope of Utility, etc., of Railway Artillery, presented by H. W. Miller, lieutenant colonel of Ordnance. It has likewise been prepared for publication by Lieut. Col. Miller. This report is approved for publication.

C. C. WILLIAMS,
Major General, United States Army, Chief of Ordnance.

CONTENTS.

PREFACE.

The following treatise on railway artillery was originally submitted as a part of the final report of the Railway Artillery Unit, Artillery Section, Engineering Division, Office of the Chief Ordnance Officer, American Expeditionary Forces in France. This report was made up at the close of the World War of 1914–1918, and was a revision of a similar report prepared by the undersigned in April, 1918. The second report was finished and submitted in August, 1919, and covered, as fully as available information would permit, all railway artillery completely or partially designed by ourselves, our allies, and our enemies in that war.

In preparing this revised report, two factors were kept particularly in mind with reference to the change in railway artillery requirements of the United States Army, which had taken place since the completion of the first report.

The first factor is the time available for the construction of the artillery, throughout the period of active warfare. The aim was to mount, in the shortest possible time, the greatest possible number of available heavy guns on any type of mount that had been found satisfactory for land warfare in France. Only limited machine facilities were available and speed was the essence of every problem. Now that the war is ended conditions are vastly different; we are not in so great a hurry as we were a year ago, and we may assume that any, or all, machine facilities that might be required for any type of carriage are available.

The second factor is the characteristics required of the mount. During the active period of the war, as noted above, any mount which had been found satisfactory for land warfare would serve; now only such mounts as are adaptable also to coast defense should be considered for new design and construction.

It is the object, therefore, of this revised report: First, to embody in available form as much as possible of the information concerning railway artillery acquired through experience in the war just ended; and second, to indicate the application of this information and the lessons learned to the present and future problems of the Ordnance Department, the formation of a new program of construction for railway artillery.

The recommendations contained herein should not be considered official, since they have not been so approved by any regularly constituted board of the Ordnance Department. They are the final conclusions of the writer based upon over two years close association with engineering work on railway artillery both in Europe and America.

The material contained herein has been obtained from a large number of sources which may be summarized as follows:

(*a*) Examination of French railway artillery in French artillery parks, heavy artillery proving grounds, shops, and on the front.

(*b*) Examination and study of designs of railway mounts of all types, and conference with designing engineers of the Ordnance companies in France and England who have been responsible for the greater number of the railway artillery designs.

(*c*) Examination of captured German matériel and study of captured documents.

(*d*) Consultation and cooperation with Staff of American Railway Artillery Reserve and Heavy Artillery School in France.

(*e*) Study of all bulletins and regulations issued by the French and English services for railway artillery.

(*f*) Observation of French and English Railway Artillery in action and conference with Railway Artillery personnel of French, English, and American Armies.

(*g*) Eighteen months cooperation with the French services directing the design, manufacture, maintenance, and field service of railway artillery.

Particular reference is made throughout the text to specific publications, etc., listed under the bibliography, from which data has been secured, or in which additional information may be found.

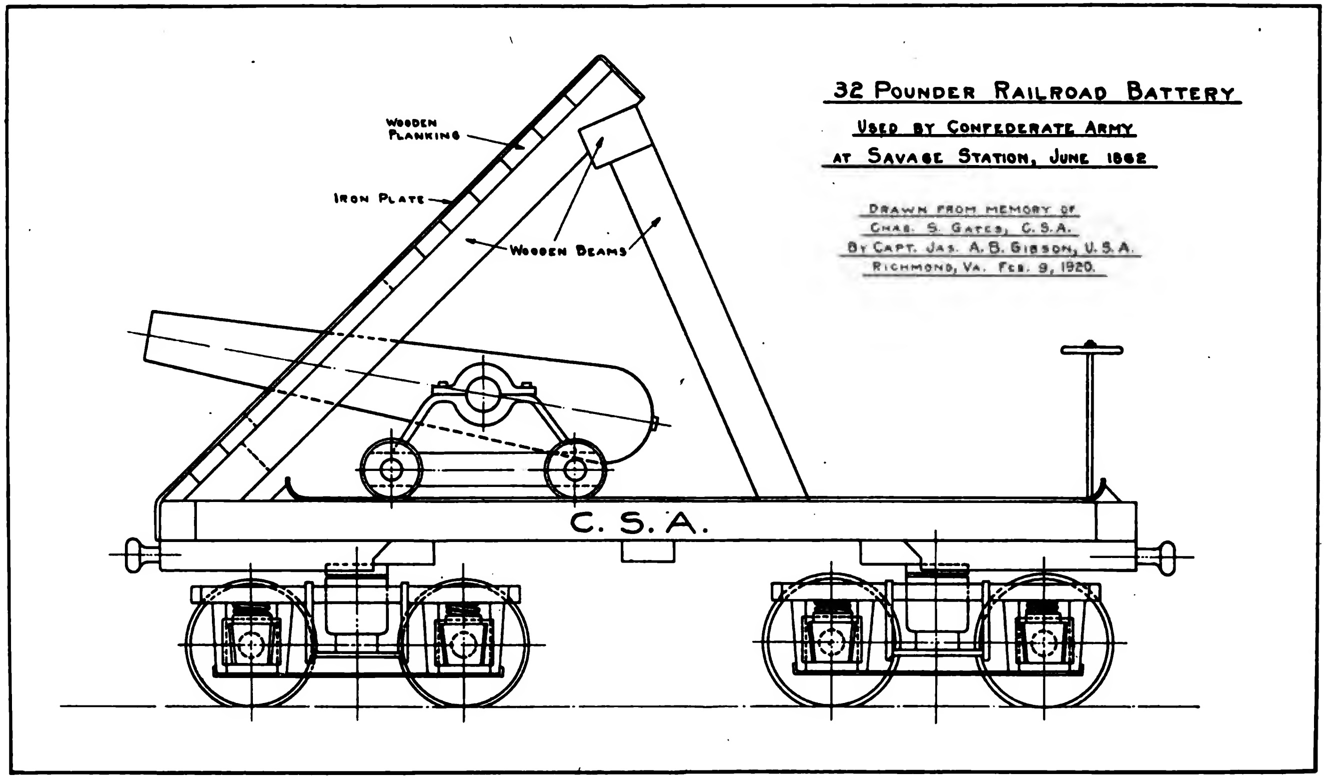
Much of the material given in the descriptions of the mounts belonging to our allies in the European war as well as the tabulated data on weights, ballistics, etc., is considered by these allies as being confidential and, at their request, is printed and issued to our service as such. For this reason the report has been divided and is published in two parts. The one part contains all information of a general character, as well as the descriptions and tabular data on the American and German mounts. The other volume contains descriptions and tabular data on all of the French, British, and Italian mounts and is issued as a confidential publication and is not for general distribution; it is available only for official Army use. This, of course, includes its use as a reference work in regularly constituted Army schools.

The description of the German long-range gun and of the bombardment of Paris given under the heading of Appendix I is considered as going properly in this work, because the guns instrumental in the bombardment were mounted on a railway carriage. The "Study of the relative efficiency of different calibers" given under the heading of Appendix II is included because it has an important bearing in the discussion given on the "Scope of Utility of Railway Artillery," and on the conclusions with reference to the types of guns recommended for future construction. The description of the coast defenses installed by the Germans in Belgium is given, under the heading of Appendix III, because these defenses included railway artillery and because the future problem of America with reference to railway artillery is so intimately connected with the plans on coast artillery.

The undersigned desires to acknowledge his indebtedness to Capt. W. F. Dietrichsen, who has assisted in the collection of all data and preparation of the original report, and to Maj. Hugh Pastoriza, who has assisted so effectively in preparing this revision. Appendix II on the "Relative efficiency of the different calibers" was prepared by Maj. Hugh Pastoriza and Capt. R. H. Kent.

H. W. Miller,
Lieutenant-Colonel, Ordnance Department, United States Army.

PLATE 1


32 POUNDER RAILROAD BATTERY
USED BY CONFEDERATE ARMY
AT SAVAGE STATION, JUNE 1862
DRAWN FROM MEMORY OF
CHAS. S. GATES, C.S.A.
BY CAPT. JAS. A. B. GIBSON, U.S.A.
RICHMOND, VA. FEB. 9, 1920.
WOODEN PLANKING
IRON PLATE
WOODEN BEAMS
C. S. A.

CHARACTERISTICS, SCOPE OF UTILITY, ETC., OF RAILWAY ARTILLERY.

HISTORICAL INTRODUCTION.

---

1. Railway Artillery seems not to have been recognized as an important and separate subdivision of Artillery before the outbreak of the World War, 1914-1918. For this reason the idea and the material are thought of as new developments, whereas in fact both appeared almost simultaneously with the widespread adoption of railway transportation.

2. The earliest railway artillery of which the writer has been able to find any record was employed in the Confederate Army under Maj. Gen. J. Bankhead Magruder, on June 29 and 30, 1862, at Savage Station, on the Richmond & York River Railway, about 10 miles east of Richmond, in one of the "Seven Days' Battles." A sketch of this mount according to the best data available is given in plate 1. Apparently the credit for the conception of the idea for the construction of such a battery should be given to Gen. Robert E. Lee. Following is a copy of the correspondence between Gen. Lee and the authorities in Richmond responsible for the construction of the mount:

[A.—Official records of the War of the Rebellion, Volume XI, part 2, page 574 (1).]

HEADQUARTERS, *June 5th, 1862.*

Col. J. GORGAS,
Chief of Ordnance Dept.

COLONEL: Is there a possibility of constructing an iron-plated battery, mounting a heavy gun on trucks, the whole covered with iron, to move along the York River Railroad? Please see what can be done. See the Navy Department and officers. If a proper one can be got up at once, it will be of immense advantage to us. Have you got any mortars that we could put at some point on the railroad?

Very respectfully,

R. E. LEE, *General.*

[B.—Same reference, pages 575-576 (1).]

HEADQUARTERS, *Near Richmond, Va., June 5th, 1862.*

Capt. GEORGE MINOR,
Chief of Ordnance and Hydrography:

The Armstrong gun, if mounted on a field carriage with its supply of projectiles, will be of immense importance to us. Can we not have it in the morning? The smaller gun (Parrott) I think we have enough at present. I am very anxious to have a railroad battery. I wrote to Colonel Gorgas on the subject this morning and asked him to get you and Brooke to aid him. Till something better could be accomplished

I propose a Dahlgren or columbiad, on a ship's carriage, on a railroad flat, and one of your Navy iron aprons adjusted to it to protect gun and men. If I could get it in position by daylight tomorrow, I could astonish our neighbors. The enemy cannot get up his heavy guns except by railroad. We must block his progress.

Very respectfully and truly,

R. E. LEE, *General.*

[C.—Same reference, page 610 (1).]

HEADQUARTERS, *Dubb's House, Va., June 21, 1862.*

Hon. S. R. MALLORY,
Secretary of the Navy, Richmond, Va.

SIR: I have been informed by Colonel Gorgas that the railroad battery will be ready for service tomorrow. Inasmuch as this battery has been constructed by the Navy, I would be pleased if you would assign an officer and a requisite number of men to take charge of and operate it. If you desire to do so, I request that you will designate the officer at once, as I wish to place the battery in position tomorrow. I am very much obliged to you for your kindness as well as promptness in its construction.

I am, very respectfully, your obedient servant,

R. E. LEE.

[D.—Same reference, page 615 (1).]

OFFICE OF ORDNANCE & HYDROGRAPHY,
Richmond, Va., June 24, 1862.

General R. E. LEE,
Comdg., &c., near Richmond, Va.

GENERAL: The railroad iron-plated battery designed by Lieut. John M. Brooke, C. S. Navy, has been completed. The gun, a rifled and banded 32-pounder of 57 cwt., has been mounted and equipped by Lieut. R. D. Minor, C. S. Navy, and with 200 rounds of ammunition, including 15-inch solid bolt shot, is now ready to be transfered to the Army. I have the honor to be,

Very respectfully, your obedient servant.

GEORGE MINOR,
Commander, in Charge.

Numerous records are available of the service of this mount in the battle mentioned. Following are extracts from some of these records and references to others:

[E.—Official records of the War of the Rebellion, volume XI, part 2, page 664.(1)]

EXTRACT FROM REPORT OF MAJ. GEN. J. BANKHEAD MACGRUDER, C. S. A., OPERATIONS JUNE 29–30, 1862, AT SAVAGE STATION.

Taking my position on the railroad bridge, which commanded a good view of the fight and the enemy's line of battle, I directed the railroad battery, commanded most efficiently by Lieutenant Barry, to advance to the front, so as to clear in some degree, the deep cut over which the bridge was thrown, and to open fire upon the enemy's masses below, which was done with terrible effect. The enemy soon brought the fire of his artillery and infantry to bear upon the railroad battery and bridge while he advanced a heavy line of infantry to support the troops already engaged to capture our artillery and turn our right flank.

[F.—Same reference, pages 717–718.(1)]

EXTRACT FROM REPORT OF MAJ. GEN. LAFAYETTE M'LAWS, C. S. A., DATED JULY 20, 1862.

Lieutenant Barry of the artillery had been for some days previous placed in charge of a 32-pound rifled gun, mounted on a rail car and protected from cannon shot by a sloping roof in front, through which a porthole had been pierced, and from rifle shots on the sides by thick walls of wood lined with iron. His battery moved down the road, keeping pace with the advance of the troops, and by his fire annoyed the enemy whenever the range would allow.

[Battles and leaders of the Civil War, volume 2, page 373.(2)]

(Here will be found a report made by Maj. Gen. Wm. B. Franklin, United States Army, describing the approach of the railway battery used at Savage Station.)

[Same reference, page 374.(2)]

(Here will be found a sketch showing the opposing forces at Savage Station and the marked location of the railway battery.)

Gen. Joseph L. Brent of the Confederate Army mentions in his book "Mobilizable fortifications" (3), first published in 1865, and republished in 1916 by Williams & Wilkins Co., Baltimore, that a 32-pounder gun was mounted on a standard flat car and operated at a point called Savage Station on the Richmond and York River Railway. To quote, he says:

However, it was my fortune to witness perhaps the first fire that was ever delivered in actual combat from an armored railway wagon.

During the American Civil War, in 1862, the Confederate authorities prepared in Richmond a railway battery armored with railroad iron and carrying a 32-pounder gun in front of the engine. The iron shield only covered the front of the battery, and was pierced by an embrasure, but the sides and rear were unprotected.

When, in June, 1862, Lee made his flank movement against McClellan, one of the Seven Days' Battles was delivered on the line of the Richmond and York River Railway, at a point called Savage Station.

The iron railway battery was sent out on this road from Richmond, and Maj. Gen. MacGruder, commanding the Confederates at Savage Station, ordered this battery to advance and fire on the enemy.

It moved, propelled by steam, down the track, and passed into a deep cut, and from this cut opened with its 32-pound gun, and burst its shell beyond the first line of the Federals, and over the heads of their reserves, forcing them to shift their position.

About the same time the skirmishers of the opposing forces became engaged and the lines of battle were deployed, resting on the right side of the railway.

The Union line was a little beyond the cut from which the railway battery fired, and at right angles to it. If the battery had advanced it would have completely enfiladed the Union line at short range, and must have broken it; but owing to the fact that the sides and rear of the battery were open and exposed to the fire of the skirmishers, and to the further fact that the field of fire of the gun was limited by its embrasures, the battery could not advance; and as the skirmish fire approached, it withdrew. If guns had been mounted "en barbette" and the gunners and machinery protected by only bullet-proof armor, and if there had been half a dozen such batteries, they could have easily broken the Federal line of battle and have cut off their reserves, large numbers of which were stationed on the left of the track.

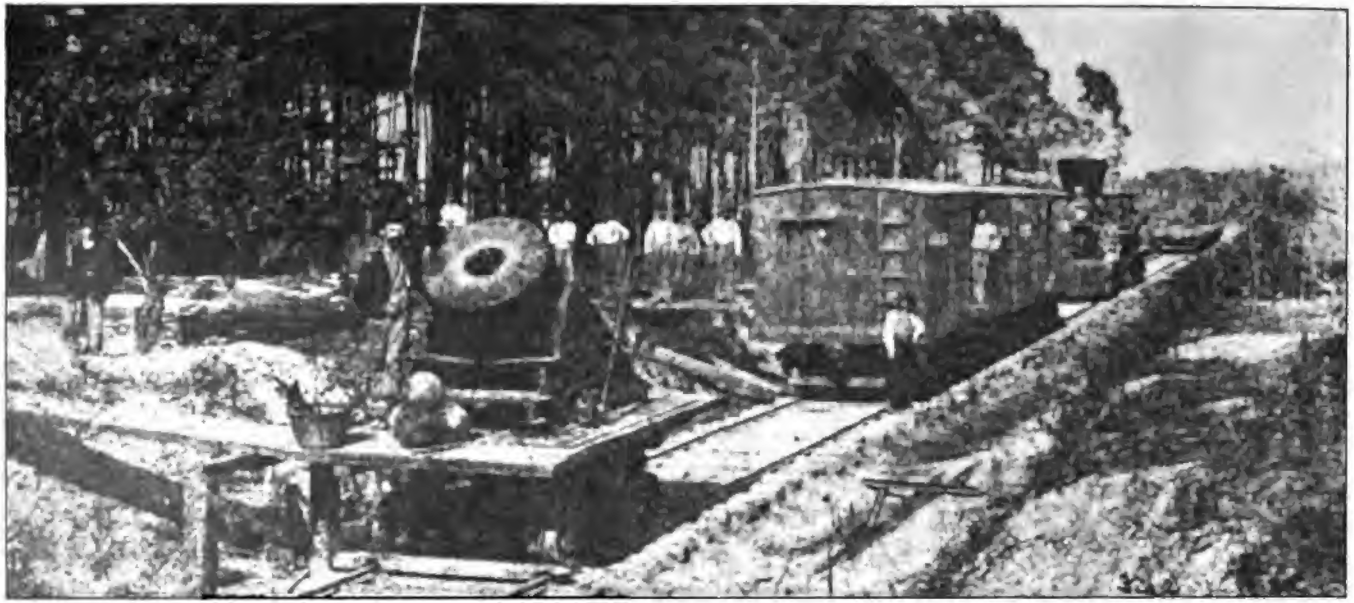
Particular attention is invited to Gen. Brent's book. During the Civil War he had been particularly impressed with the effectiveness of the Union gun boats operating on the larger rivers and in the bayous at the mouths of the smaller rivers, especially in Louisiana, Alabama, etc. He was thoroughly convinced of the futility of fortifying inland cities against siege by means of masonry forts, etc., and was much impressed by the effectiveness of the Union gunboats just noted, with the possibilities of fortifying and protecting any large railway center by means of artillery of all calibers mounted on railway carriages. Some time before 1870, while in France, a discussion that he had with reference to this scheme of fortifying inland cities came to the ears of Napoleon III, who called Gen. Brent into a conference with reference to the practicability of his scheme in fortifying Paris. Napolean was so much impressed with its possibilities that he detailed several officers to conduct Gen. Brent on a tour of inspection of the fortifications of Paris. These officers were likewise impressed with the possibilities of the scheme and submitted to Napoleon a report recommending its adoption. This report was forwarded by Napoleon to his army staff and was quite unfavorably received; as a consequence the plan was rejected. Gen. Brent discusses the Franco-Prussian War of 1870, commenting particularly on the sieges of Metz and Paris.

3. William P. Brady's Civil War Pictures contain several excellent photographs of two designs of artillery that were used by the Union Army in their siege of Petersburg in 1864. One of these guns, plates 2 and 2A, was a 13-inch muzzle-loading mortar, 2.7 calibers in length. This mortar weighed 17,000 pounds, used a spherical shell weighing 220 pounds, and a powder charge of 20 pounds. The records available indicate that this mortar had a range between 3 and 4 miles and did effective work in the siege. It will be noted in plate 2 that the car on which the mortar is mounted seems to be made up of two standard trucks on which an improvised platform has been placed. It is understood that this carriage failed after the mortar had been fired several times and that thereafter the practice was to transfer the mortar and its platform, as shown on plate 2A, from the railway car to a more solid foundation. This railway mount was called "The Dictator" and "Petersburg Express." On plate 3 is shown another mount photographed by Brady which in his records is also described as having been used in the siege of Petersburg.

4. Another reference to what was likely though not certainly the 13-inch mortar discussed before is given in Professional Papers, Corps of Engineers, No. 14, Siege Artillery in the Campaign Against Richmond, by Bvt. Brig. Gen. Henry L. Abbott, United States Army, 1868 (5). The following is quoted from page 23, referring to the campaign of 1864:

> The great weight of the 13-inch mortar (17,000 pounds) renders it difficult to move and some satisfactory experiments were made with a novel platform. An *ordinary railroad platform car* (eight wheels) was strengthened by additional beams tied strongly by iron rods and was plated on top with iron.

PLATE 2



THIRTEEN-INCH MORTAR (DICTATOR OR PETERSBURG EXPRESS) (FIRING FROM TRACK).

PLATE 2A

THIRTEEN-INCH MORTAR THROWING SHELLS INTO PETERSBURG IN 1864 (FIRING NORMAL TO TRACK).

PLATE 3

RAILWAY BATTERY USED IN SEIGE OF PETERSBURG.

The mortar was placed upon this car (top of mortar 9 feet above track), and run down on the City Point Railroad to a point near our lines where a curve in the track afforded facilities for changing the plane of fire by advancing the car or drawing it back. The mortar fired with 14 pounds of powder, recoiled less than 2 feet on the car, which moved 10 or 12 feet on the track. The effect of the charge was taken up without damage to the axles, even when the full allowance of 20 pounds of powder was used. This mortar, whose shell would crush and explode any ordinary field magazine, excited dread among the Confederate gunners, and was effective in inducing their enfilading batteries on Chesterfield Heights to discontinue fire upon the right of our line. Its practice was excellent. At the Battle of the Mine, as reported by three different observers stationed at different points, the explosion of one of its shells blew a Confederate field gun and carriage above the parapet at a range of about 3,600 yards.

Of course with this platform the plane of the fire must be nearly parallel to the track or the mortar will be dismounted, but by placing the car on a curve a very considerable traverse can be secured without difficulty.

The fact that Gen. Abbott mentions that this mortar which operated against Richmond was mounted on a standard flat car seems to indicate that it is not the same mortar that was photographed by Brady at Petersburg. The mortar carriage shown in plate 2 is apparently improvised, the two trucks being practically together.

5. In the "Revue d' Artillerie," volume 7, 1876, page 8, (6) a railway mount used by the British service for proof work is described. This carriage consisted of a rigid body of steel mounted on two six-wheel trucks; there was no recoil mechanism. The following data is given with reference to weights and dimensions: Weight of truck with gun carriage, 38 tons; weight of powder charge, 108.9 kilograms; muzzle velocity, 472.4 meters per second; recoil length, 11.63 meters up a 2.5 per cent grade.

6. Mention is made of a proof mount employed by the British for a 26-ton gun in the proceedings of the Institute of Civil Engineers, November 22, 1881, (7) under the discussion of the effect of recoil on field carriages. This mount consisted of an ordinary coast type of gun lift carriage mounted on two four-wheel trucks and is similar in many respects to some of the Schneider mounts, improvised from coast defense guns and used in the European War. Apparently this mount was used as a rolling recoil mount and was not anchored to the track. In the discussion, it is mentioned that the total recoil of the gun on the carriage was 3 feet and that the movement of the railway car began when the gun had reached its maximum velocity, i. e., after a recoil of about 6 inches.

7. In the minutes of the proceedings of the Royal Artillery Institute, volume 15 of 1888, (8) there is an article dealing with experiments made at Delhi, India, January, 1886, with a 40-pounder breech-loading gun on a wooden naval carriage. The railway cars on which this carriage was successively mounted were of 1 meter

gauge. The naval carriage mentioned above, carried the gun directly with no recoil mechanism. Two types of cars were employed; the first was a light four-wheel car, 6.5 by 13.5 feet, and provided with a wrought-iron underframe. The weight of the car, light, was 2.87 tons and with the gun, 9 tons; the second was an eight-wheel car 7 by 25 feet and was constructed entirely of wrought iron. The weight of this gun was 5.4 tons. Wood wedges were put under the car against the sleepers and props were also employed. The guns were fired at right angles to the track. Firing proved both of these arrangements to be unstable, although the eight-wheel car jumped much less than the four-wheel car. In subsequent experiments the car was loaded with rails to a total weight of 19 tons, and the gun was placed over the forward truck with its center line 7 feet 0.5 inches above the rail. This appeared to give satisfactory results with the eight-wheel car. The truck springs were deflected 0.437 inches, but the wheels were not lifted from the track. The conclusion stated in this article is that the scheme is suggested as satisfactory, although much would probably be gained by clamping the mount to the rails. It is mentioned that the oscillation of the car is so great that a man could probably not stand on it during firing.

8. A description is given of experiments made by the British in 1896 in the "Revue d' Artillerie," volume 50, page 34, of 1894, (9). These experiments were made on the railroad between Brighton and New Haven with a train of armored cars on which field guns were mounted. It was possible to fire these guns in all directions. The cars were solidly fixed to the rails by special brakes and remained stationary even when the guns were fired in the direction of the track. In certain French publications, (10) mention was found of the fact that both the Krupp and Skoda works conducted experiments between 1890 and 1900 on the use of the light field guns mounted on railway carriages.

9. The first concrete results of the interest of the French Technical Service in railway artillery appeared in the eighties when Gen. (then Col.) Peigne became its advocate. The first papers appeared in about 1883, and his work culminated in experiments carried on with the 155-millimeter Howitzer in 1888, and the construction of material developed from these experiments for the coast defenses of Denmark, plates 4 to 7. About the same time the St. Chamond Co. developed a disappearing carriage on railway wheels for the defense of fortifications and coasts. Carriages of this type mounting 120-millimeter guns, plate 8, were furnished the Swiss Government for the defense of the Rhone Valley.

10. The second actual employment of railway artillery in warfare, of which record is available, was by the British in the South African

PLATE 4

RAILWAY CARRIAGE FOR 155 MM. HOWITZER AND 120 MM. GUN. CARRIAGE DESIGNED BY PEIGNE-CANET IN 1888.

Plate 5

PEIGNE-CANET CARRIAGE MOUNTING 120 MM. GUN. (THIS CARRIAGE WAS USED BY AMERICAN FORCES IN THE PRESENT WAR.)

PLATE 6

GUN CARRIAGE OF 155 MM. HOWITZER ON RAILWAY MOUNT.

PLATE 7

GUN CARRIAGE OF THE 120 MM. RIFLE ON RAILWAY MOUNT.

PLATE 8

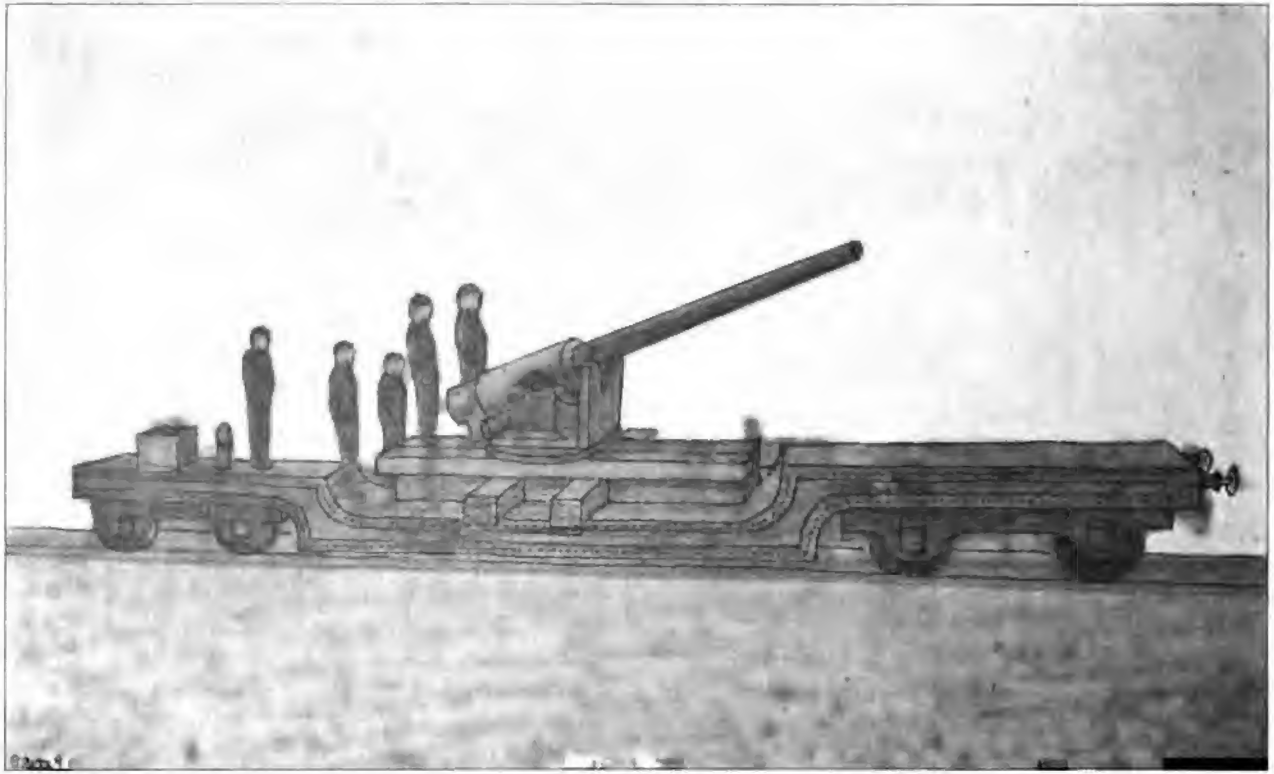
120 MM. GUN (DISAPPEARING CARRIAGE), ON RAILWAY MOUNT USED BY THE SWISS GOVERNMENT FOR THE DEFENSE OF THE RHONE VALLEY.

War in 1899-1900. One reference to the guns used in this war is found in the lecture given by Capts. Percy Scott and H. A. Limpus in Hongkong, and published by the Hongkong Daily Press on June 13, 1900, (11). In this lecture mention was first made of the 4.7-inch gun mounted on a railway carriage and used at Ladysmith. The mounting for this gun consisted of four pieces of timber 14 feet long by 12 inches square, plate 9, placed in the form of a cross. The ordinary ship mounting was arranged on the center of this and held in place by bolts passing through to a steel plate underneath. The gun carriage was set over the spindle of this mounting and screwed down by its clip plate. The railway car on which this cross of heavy wood beams was placed was an eight-wheel drop frame flat car. The lecture further mentioned that while the army was operating in the Spion Kop direction, Gen. Barton who was active at Chievely wanted a 4.7-inch gun mounted on a railway carriage to shell a new position that had been occupied by the Boers. There was no time to make a new mounting, so one of the platform mountings similar to those sent to Ladysmith was placed on a low truck and secured down with chains. The ends of the transverse timber were cut off to allow the carriage to pass through the tunnels. Very little recoil was transmitted to the track and the gun could be fired across the track satisfactorily. The mount was arranged for removal from the car and installation on the ground by the use of supplementary beams, replacing those partially cut off. Three more mounts like this were made up and used against the Boers in the attack at Pieters Hill.

11. The limit of development of this type of artillery prior to 1914 appears to have been the 200-millimeter howitzer mounts, plate 10, constructed by the Schneider Co. for the Peruvian Government in 1910. These represented really very little advance over the ideas of Gen. Peigne as worked out by Canet over 20 years previously.

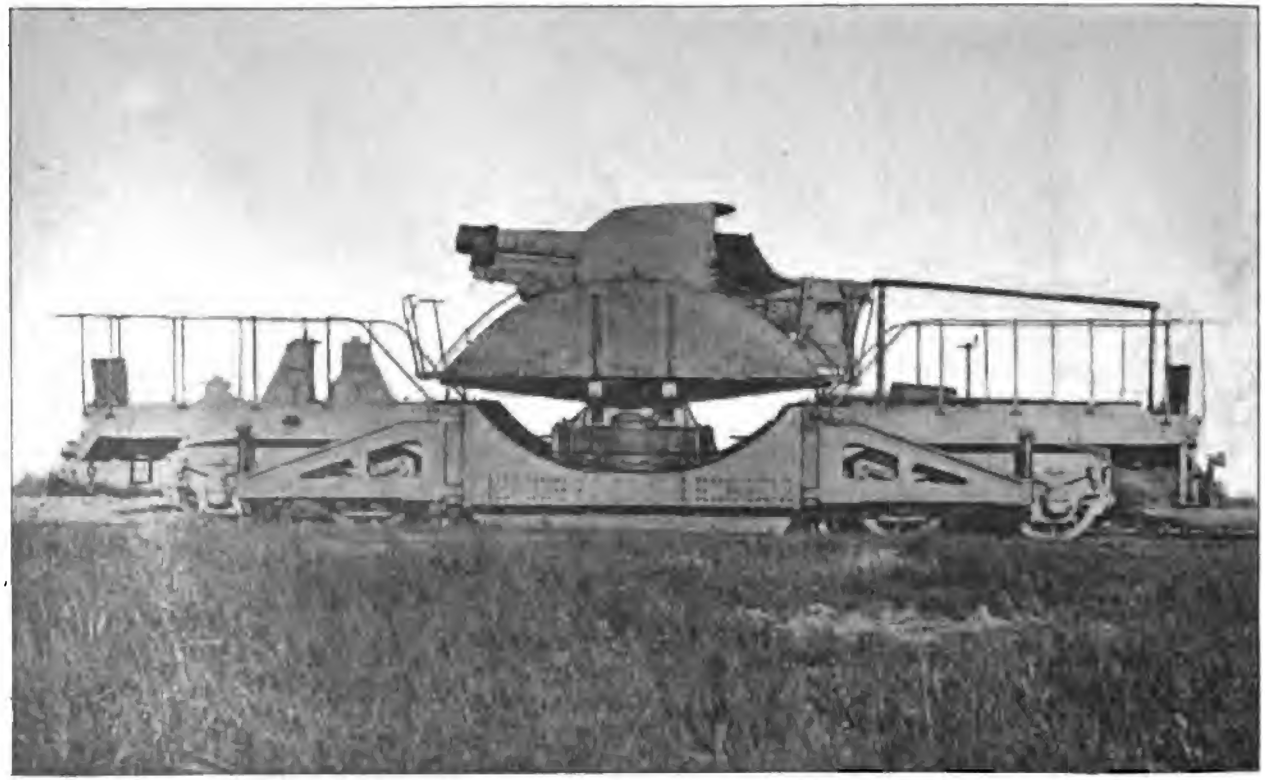
12. The invasion of Belgium in 1914 gave the first intimation of the great German 42-centimeter mortars. There is evidence to indicate that some of these were mounted on railway carriages. Others were mounted on wheeled carriages. A little later the French improvised a mount for their 305-millimeter gun.

13. In the Engineer for September 3, 1915, 12 photographs are given showing 4.7 and 6 inch guns, mounted on platform cars and with shields over them. A photograph is given also of a 12-pounder mounted on the car. These mounts were manufactured and used in South Africa. All of them were improvised from available guns and locomotive and tender trucks, except in the case of the 12-pounder mount, for which a standard two-truck car was employed. These mounts were provided with swinging arms and jack screws extending



4.7-INCH BRITISH NAVAL GUN MOUNTED ON RAILWAY CARRIAGE AND USED IN THE SOUTH AFRICAN WAR AT LADYSMITH.
(Artist's sketch.)

PLATE 10



200-MM. HOWITZER ON RAILWAY MOUNT, CONSTRUCTED BY SCHNEIDER CO. FOR THE PERUVIAN GOVERNMENT IN 1910.

PLATE 10A

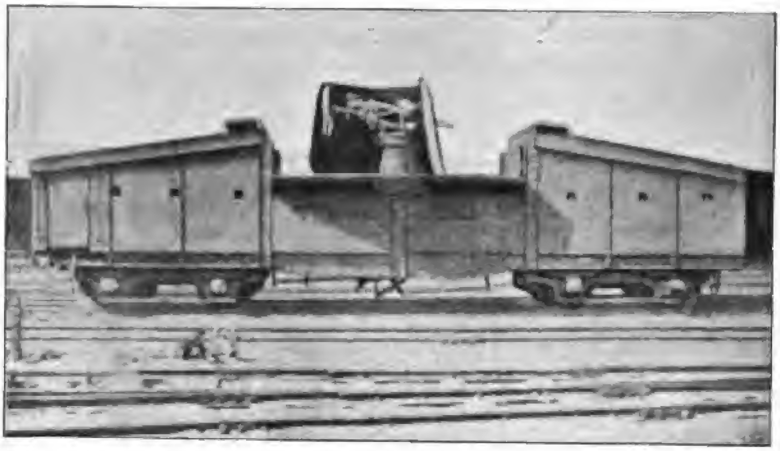


FIG. 1.

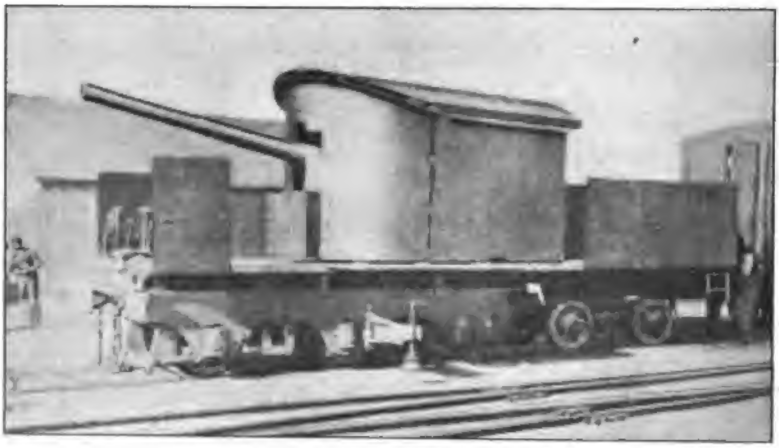


FIG. 2.

FIG. 3.

from the arms, similar to the Schneider 200-millimeter howitzer and the American original model 1918 8-inch mount.

14. The character of development of railway artillery is perhaps best illustrated by the following table of mounts already mentioned, as well as of mounts developed during the European war.

No.	Caliber.	Type.	Make.	Date.	Approximate muzzle energy.
					Tons-meters.
1	13-inch	Mortar	Improvised, Civil War	1864	300
2	155-mm	Howitzer	Schneider-Canet	1887-1890	270
3	120-mm	Gun	St. Chamond	1889	368
4	200-mm	Howitzer	Schneider	1910	920
5	420-mm	Mortar	Krupp	1914	4,900
6	305-mm	Gun	St. Chamond	1915	11,200
7	520-mm	Howitzer	Schneider	1917	17,860
8	14-inch	Rifle	United States Navy	1918	19,600
9	16-inch	do	United States Army (design only)	1918	37,600

15. A comparison of the fourth, fifth, and sixth items above shows the enormous increase in power of railway artillery which took place at the beginning of the war. The seventh and eighth show the heaviest pieces actually constructed and used and the last is the heaviest mount on which design had been perfected. Thus the period of the war has seen a forty-fold development in the power of railway artillery. It is the high points of this development which will be traced in the succeeding sections.

SECTION 1.

CLASSIFICATION OF TYPES OF RAILWAY ARTILLERY.

16. The various types of railway artillery may be classified to advantage by the characteristics of three chief factors in design—traverse, recoil, and anchorage.

17. Before going into the details of these classifications it should be emphasized that a very large number of the mounts described in Volume II and used for illustrations below were designed and constructed under the greatest possible pressure, so far as time was concerned, and from whatever materials happened to be available. In consequence, many features found in them were the result of this pressure, and in many cases were inherently undesirable. In the following, an attempt is made to point out, as clearly as possible, these features which were the result of such forced improvisation.

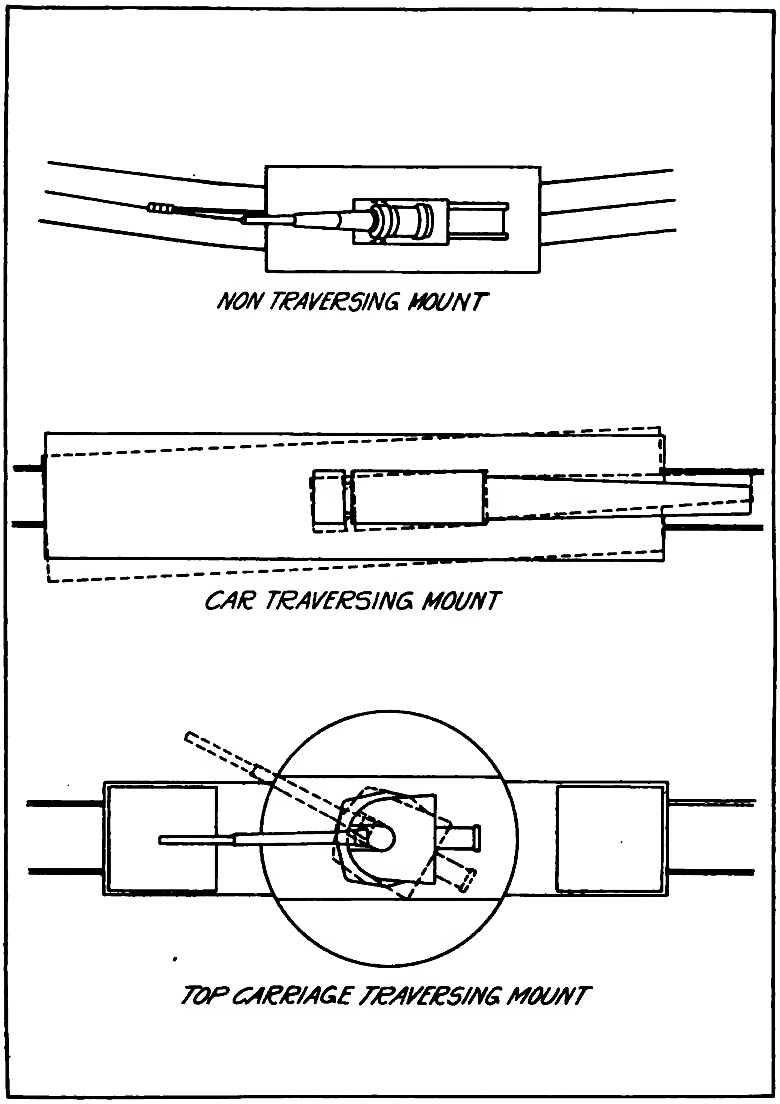
CLASSIFICATION ACCORDING TO METHOD OF TRAVERSE.

18. Traverse is obtained in railway mounts by one of three methods. These are: (1) By moving the mount along a curved track or epi (nontraversing mount); (2) by rotating the railway carriage about a real or imaginary vertical axis (car traverse); and (3) by rotating a top carriage rotable with respect to the car (top carriage traverse). For illustrations of these methods see plate 11.

19. NONTRAVERSING MOUNT.—On this type of mount no provision is made either on the gun carriage or the railway car body for traversing the gun; it can be pointed in azimuth only by moving the entire mount along a curved track.

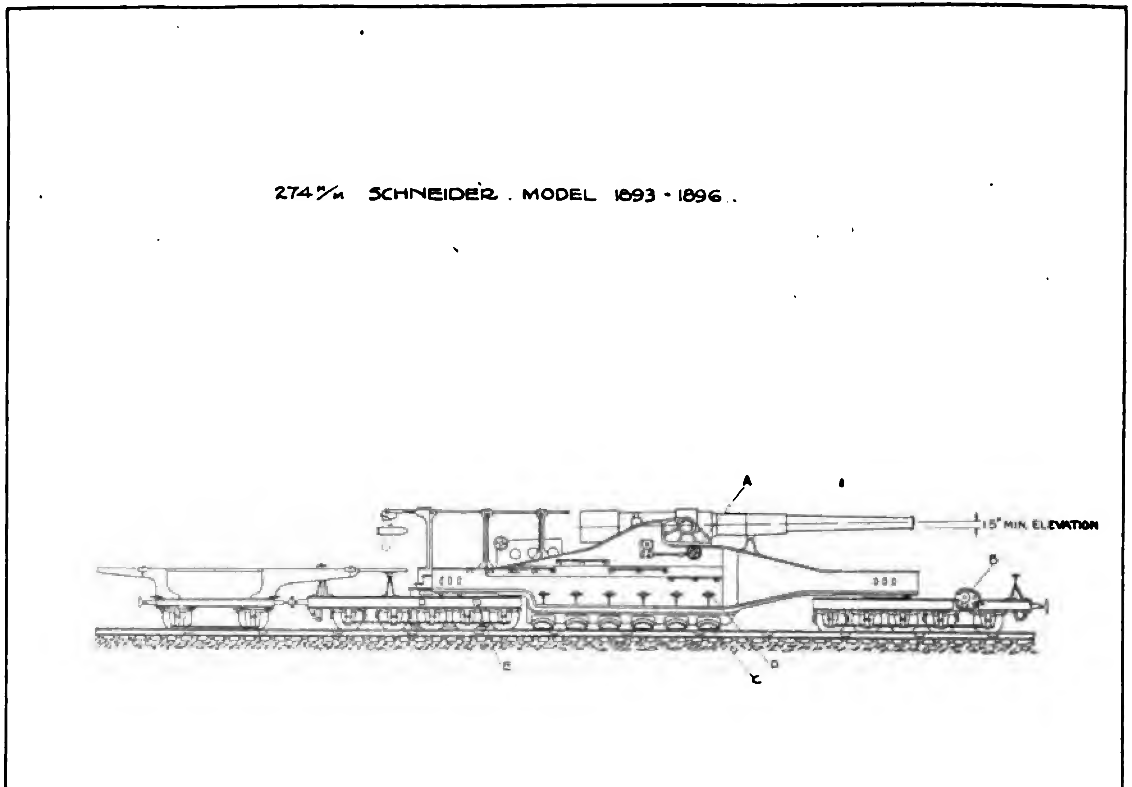
20. The most striking examples of this type are the so-called Schneider mounts on which the gun is either supported on the side girders of the car or on a gun carriage that is capable of linear motion only, and that in a direction parallel to the side girders. The first arrangement (gun supported directly on side girders) is illustrated on plates 12, 13, 14, and 15, and the second (gun on recoiling top carriage) on plates 16, 17, 18, and 19.

PLATE 11



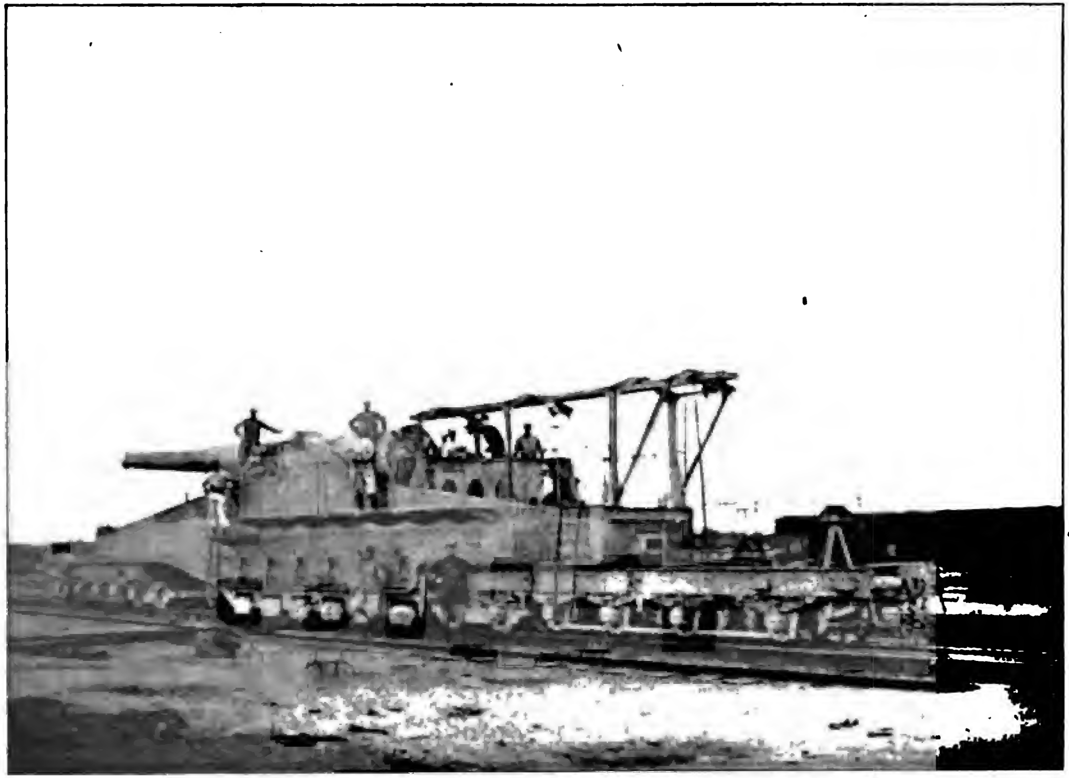
CLASSIFICATION OF RAILWAY ARTILLERY ACCORDING TO METHODS OF TRAVERSE.

PLATE 12



SLIDING TYPE MOUNT FOR FRENCH 274-MM. GUN.

PLATE 13



SLIDING TYPE MOUNT FOR FRENCH 305-MM. GUN (MOUNT SET FOR FIRING).

PLATE 14

SLIDING TYPE RAILWAY MOUNT FOR FRENCH 320-MM. HOWITZER.

PLATE 15

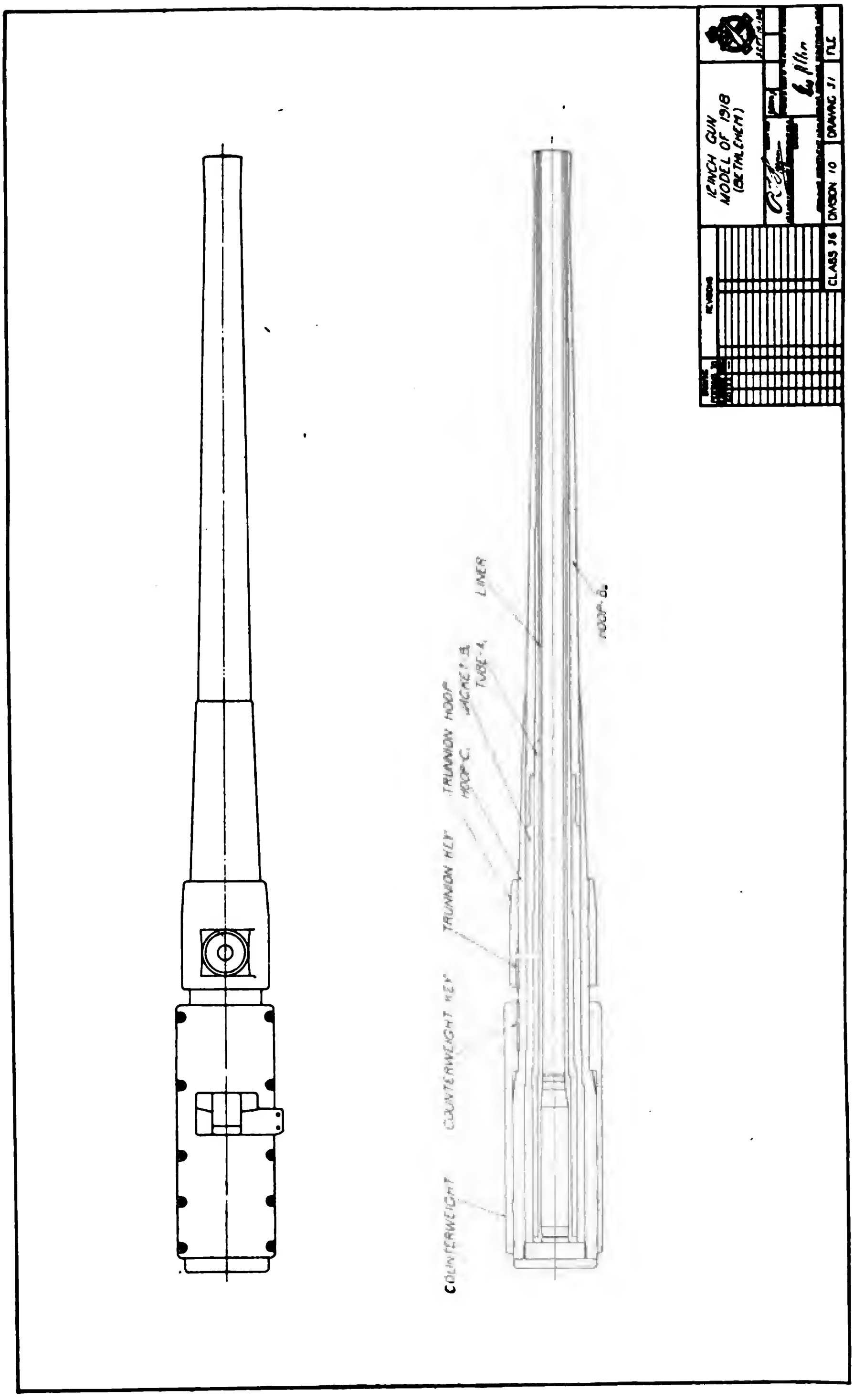
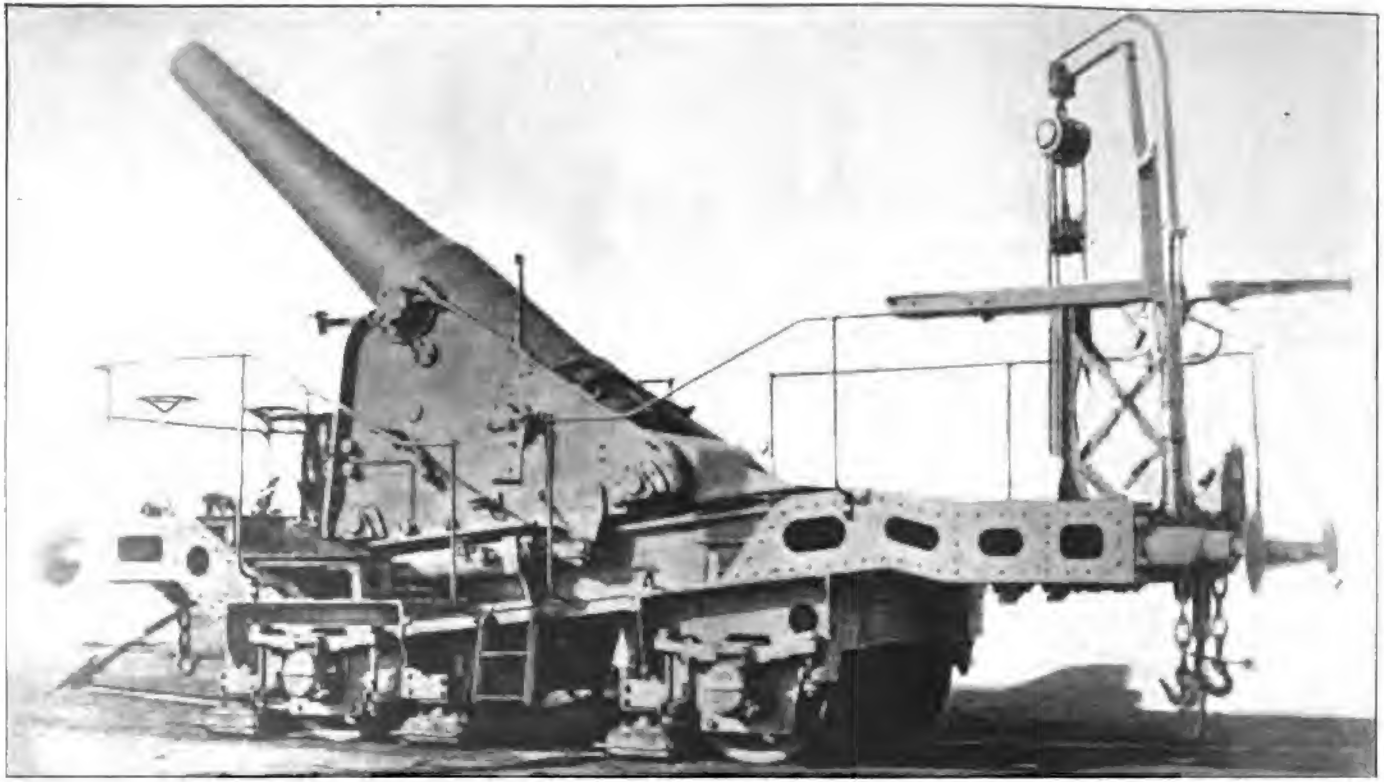
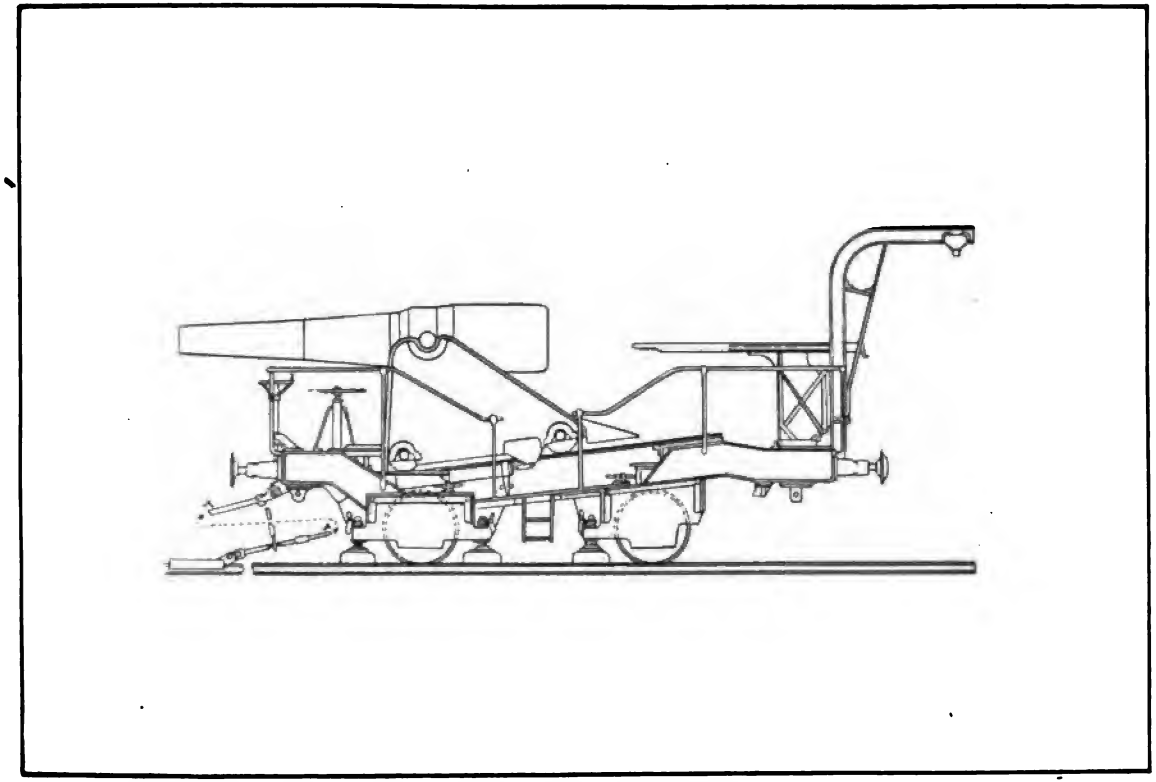

12 INCH GUN
MODEL OF 1918
(BETHLEHEM)
REVISIONS
CLASS 36
DIVISION 10
DRAWING 31
TLC
LINER
HOOP-D
TRUNNION HOOP
HOOP-C
JACKET-B
TUBE-A
TRUNNION KEY
COUNTERWEIGHT KEY
COUNTERWEIGHT

PLATE 10



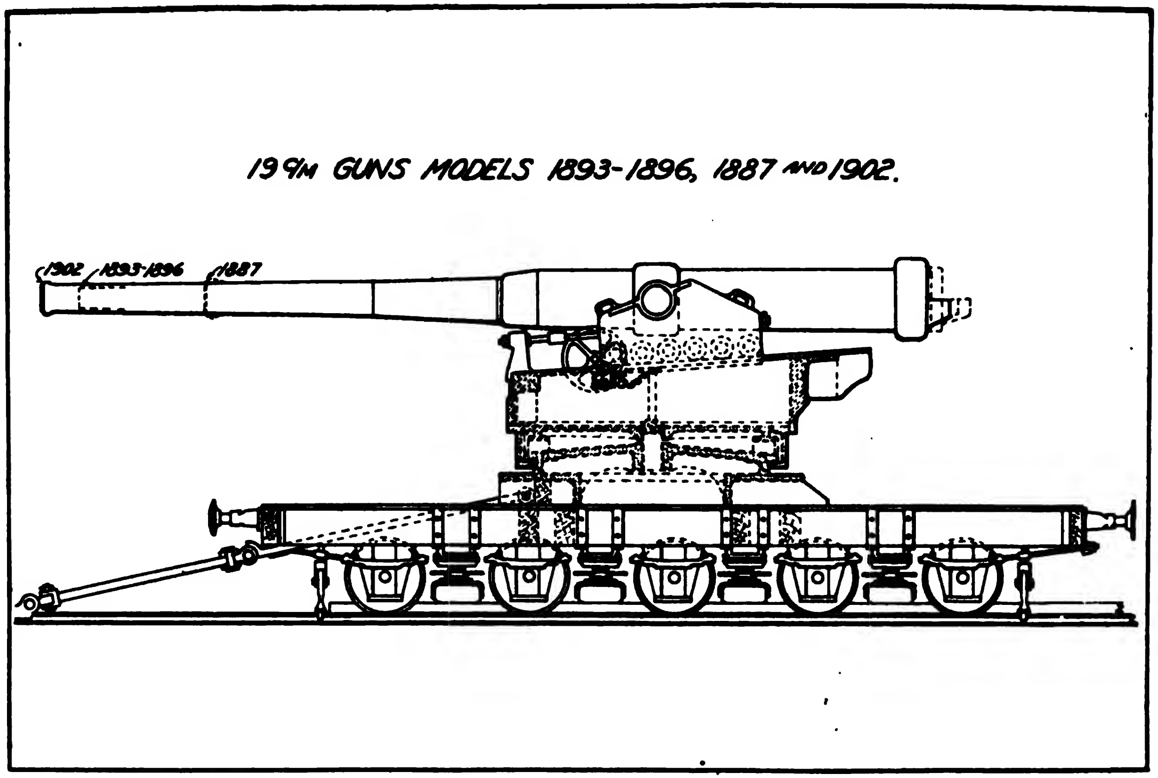
IMPROVISED RAILWAY MOUNT FOR 190-MM. FRENCH HOWITZER AND ITS SEACOAST CARRIAGE.

PLATE 17



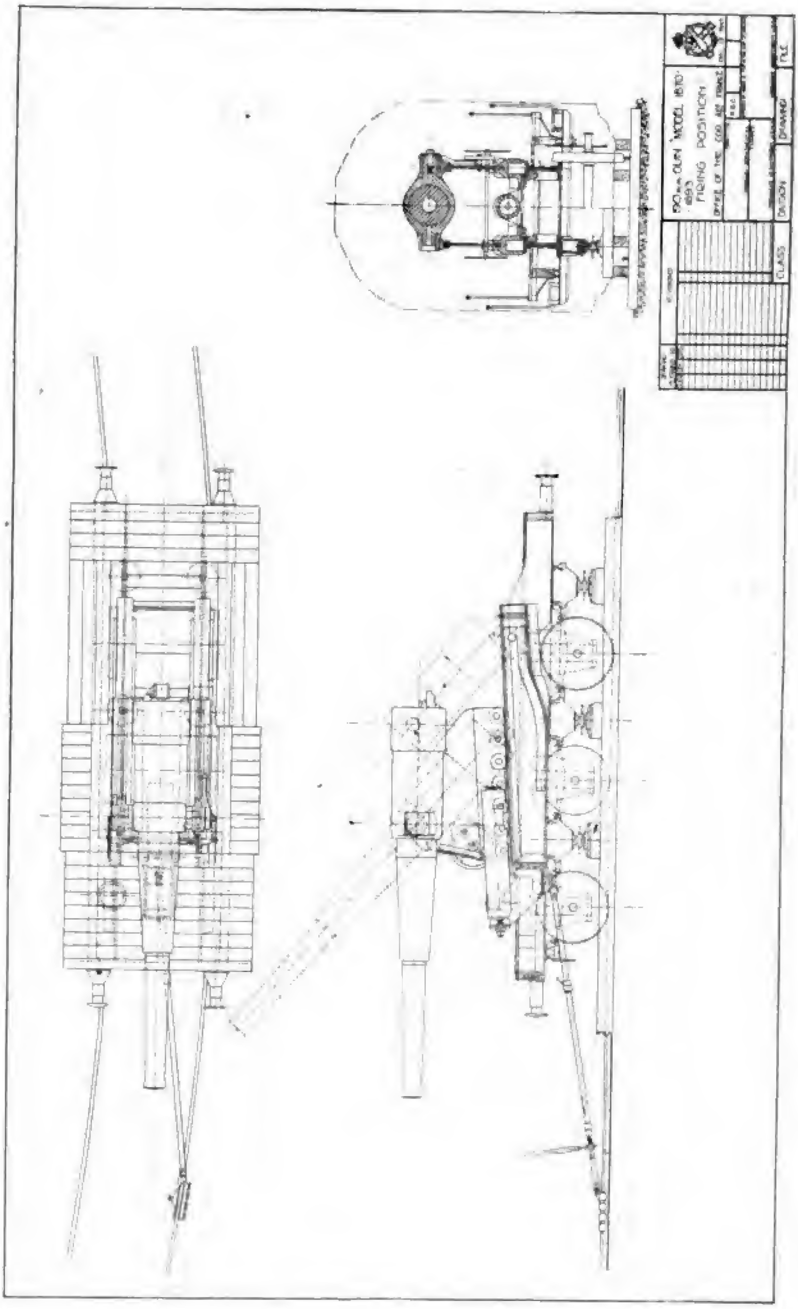
IMPROVISED RAILWAY MOUNT FOR 190-MM. HOWITZER AND ITS SEACOAST CARRIAGE.

PLATE 18



RAILWAY MOUNT FOR 19-MM. GUN AND ITS SEACOAST CARRIAGE.

PLATE 19


150mm GUN MODEL 1878-1893
FIRING POSITION
CLASS
DIVISION
DRAWING
FILE

21. Car-Traversing Mount.—The distinctive feature of this type is the provision which is made for traversing the entire car body. The gun is supported in the car body, either directly on rigid trunnions, or through a cradle or top carriage without traverse, and it can be moved in azimuth only to the extent that it is possible to traverse the car body. As a rule this traverse is obtained by a slight movement of the car body on the trucks, giving a few degrees on each side of the center line. Other mounts of this type, however, are provided with an elaborate center plate with traversing rollers and are capable of large traverse or even of all round fire. The latter type, and sometimes the former as well, require an elaborate foundation and are generally provided with a large center pin which takes the horizontal component of the shock of recoil. Car-traversing mounts affording limited fire are illustrated on plates 20, 21, 22 and 23, and one allowing large traverse or all round fire is illustrated on plate 24.

22. Top Carriage Traversing Mounts.—The distinctive feature of this type is the provision of a top carriage rotable with respect to the car body. The amount of traverse varies on the different designs in use from 10 to 360 degrees. In each of these designs, with the single exception of the American 16-inch howitzer, model 1918 MI, either a more or less elaborate firing platform or some arrangement of outriggers is required. Top carriage traversing mounts affording limited fire are illustrated on plates 25 and 26, and those affording all round fire are shown on plates 27, 28, 29, 30, and 31.

23. Discussion.—The nontraversing mounts are all, to a certain extent, improvisations. The French term them "affuts de circonstance." It is the concensus of opinion that, where time and facilities permit, a small amount of traverse at least should be given, so that the gun may be trained closely in azimuth. The distinction between the other two types seems to be more essentially on the basis of caliber and muzzle energy. The top carriage type traverse is easily applied with the smaller guns while the car-body traverse is reserved for the heavier and higher powered ones.

CLASSIFICATION ACCORDING TO RECOIL SYSTEM.

24. Recoil is taken up on railway artillery by allowing the displacement of the mount or some portion thereof and retarding this motion. Characteristic provisions are made for bringing the moving part back to its original position. Such artillery may be classified in accordance with the extent of this recoiling portion into the following well-marked systems: (1) Cradle recoil, top carriage recoil, sliding mount recoil, and rolling mount recoil. See plate 32 for illustrations of these types. The means of retardation and of return to battery

PLATE 22

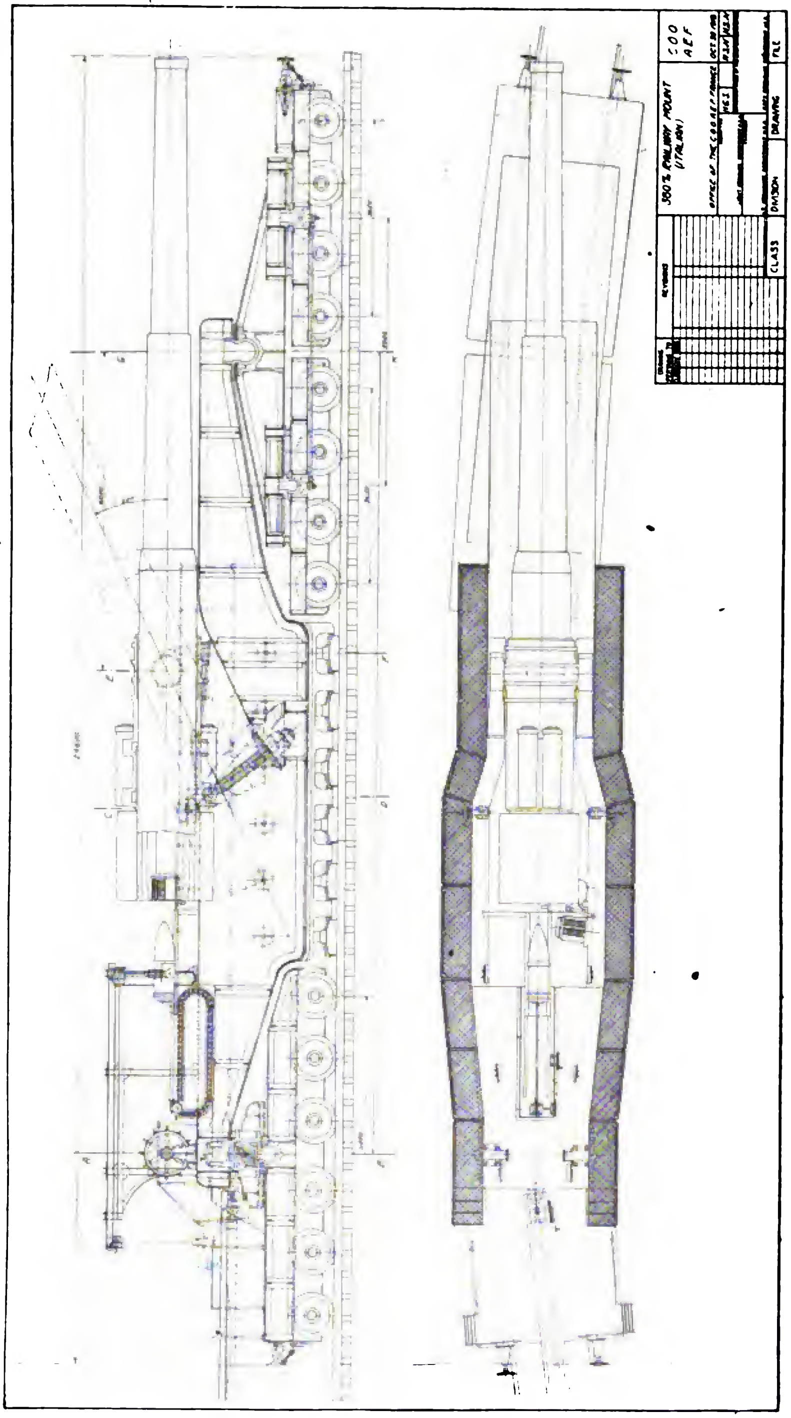


PLATE 23

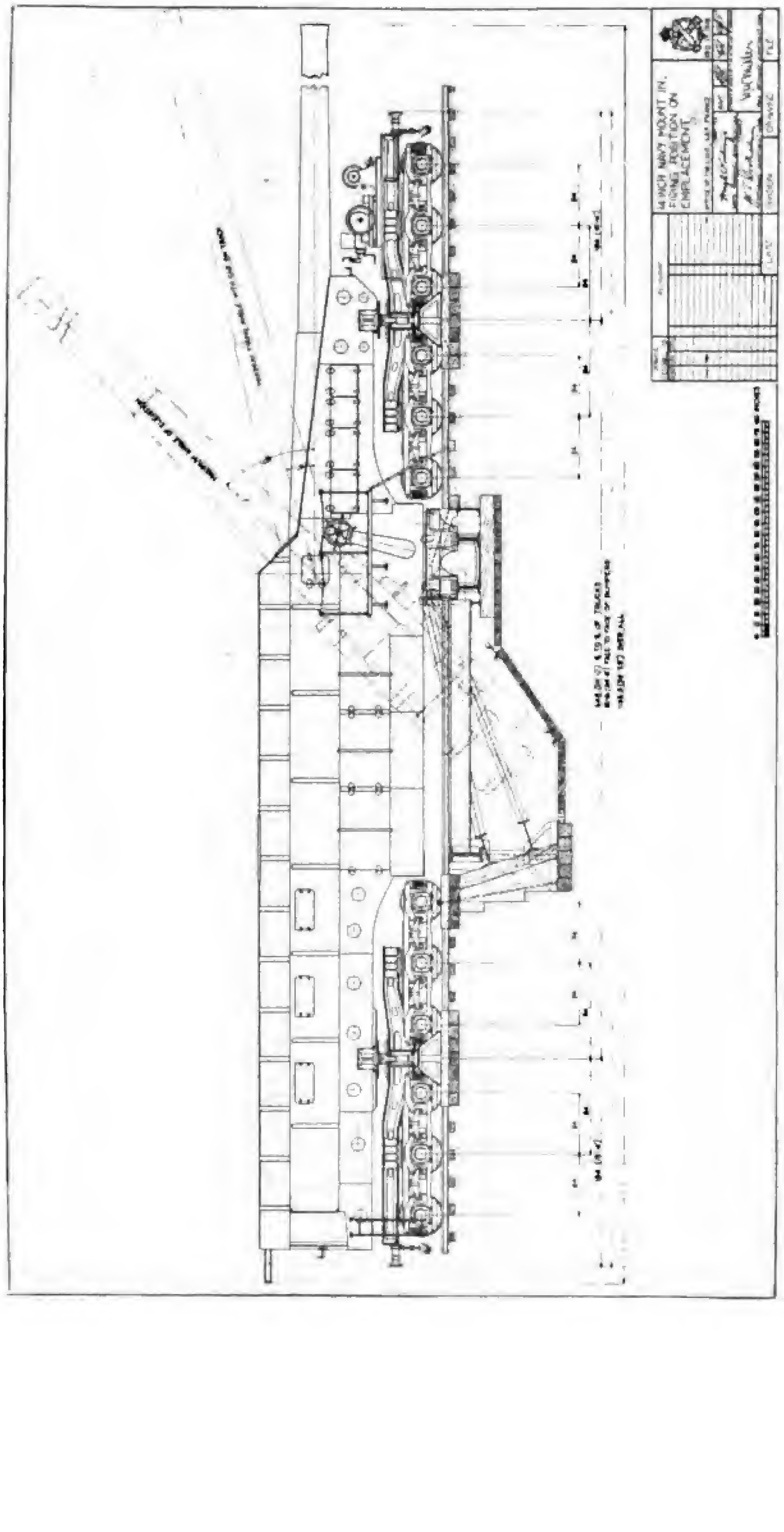
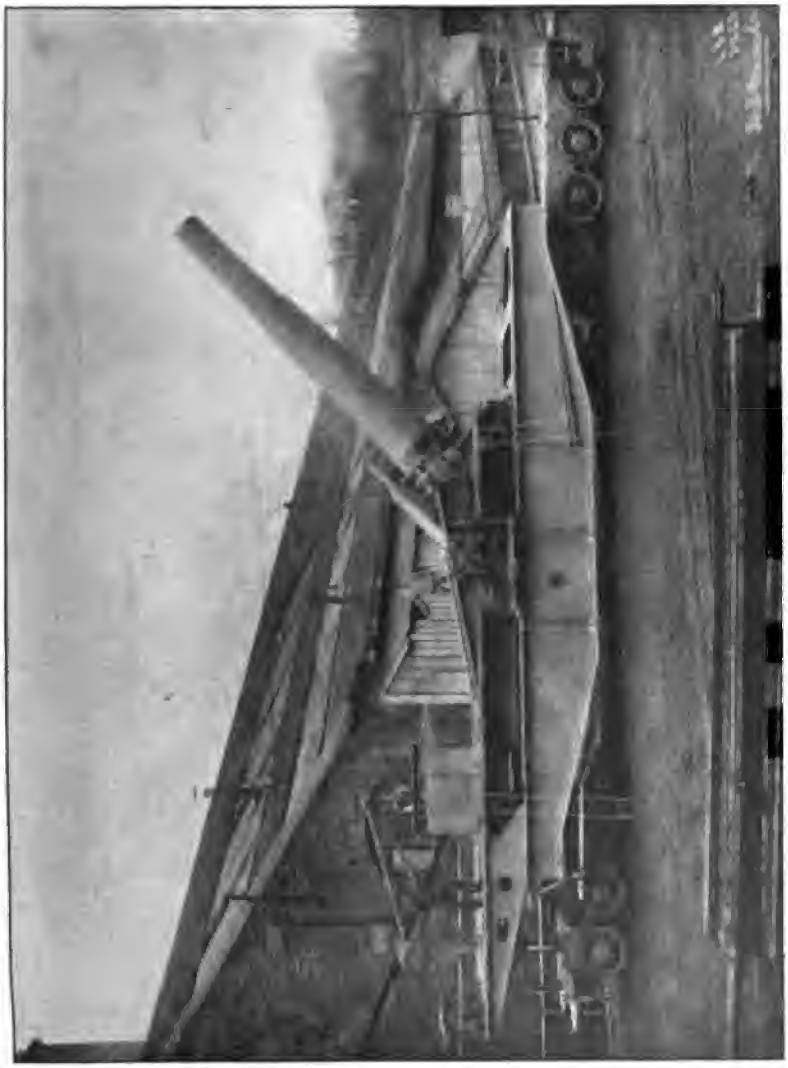


PLATE 24

RAILWAY MOUNT FOR GERMAN 280-MM. GUN.

PLATE 25



RAILWAY MOUNT FOR 400-MM. FRENCH HOWITZER.

Plate 28

BATEGNOLLES RAILWAY MOUNT FOR AMERICAN 12-INCH, 35-CALIBER GUN.

PLATE 27

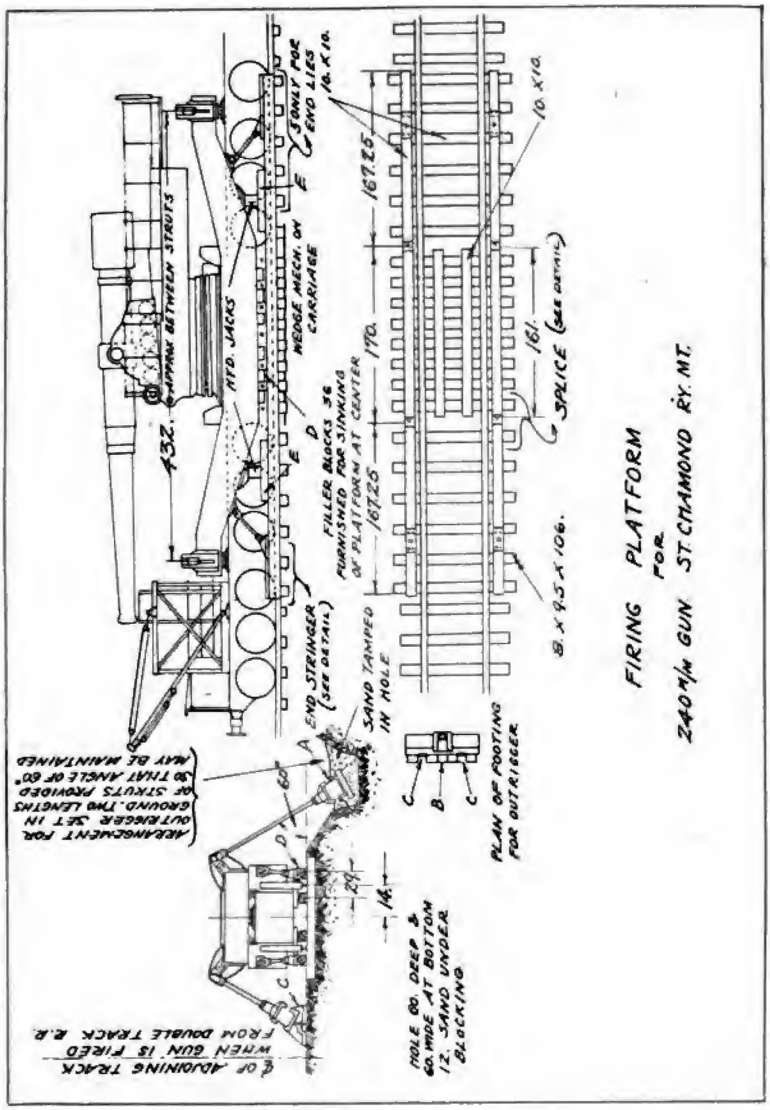
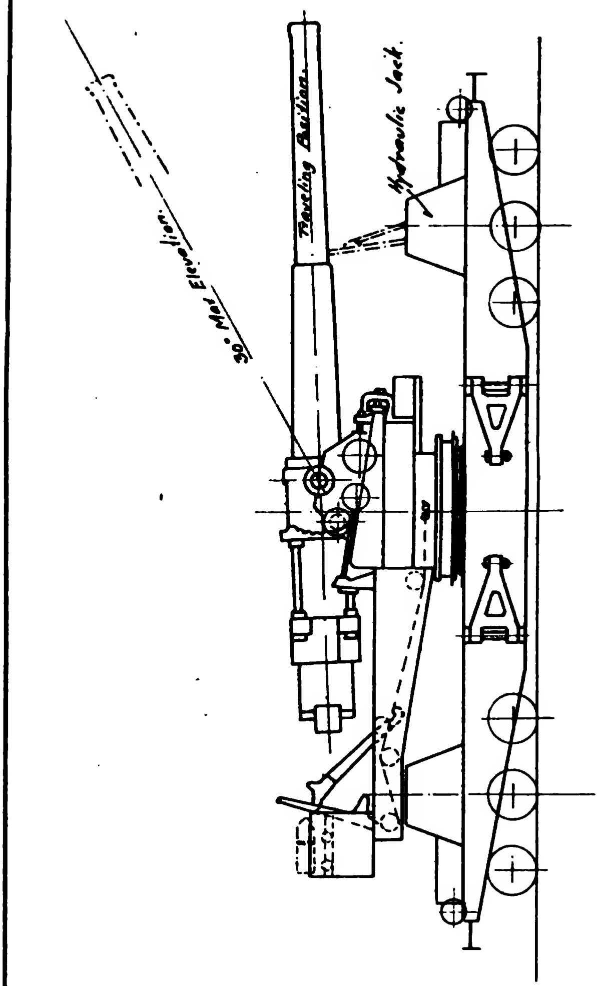

FIRING PLATFORM
FOR
240 M/M GUN ST. CHAMOND RY. MT.
HYD. JACKS
WEDGE MECH. ON CARRIAGE
FILLER BLOCKS 36 FURNISHED FOR SINKING OF PLATFORM AT CENTER
END STRINGER (SEE DETAIL)
SAND TAMPED IN HOLE
SPLICE (SEE DETAIL)
8. X 9.5 X 106.
10. X 10.
167.25
170.
161.
432.
PLAN OF FOOTING FOR OUTRIGGER
HOLE 60. DEEP & 60. WIDE AT BOTTOM 12. SAND UNDER BLOCKING
ARRANGEMENT FOR OUTRIGGER SET IN GROUND. THE LENGTHS OF STRUTS PROVIDED SO THAT ANGLE OF 60° MAY BE MAINTAINED
℄ OF ADJOINING TRACK WHEN GUN IS FIRED FROM DOUBLE TRACK R.R.

PLATE 28



MOUNTING RAILWAY TRUCK B.L. 9.2" GUN MARK III.

12·IN

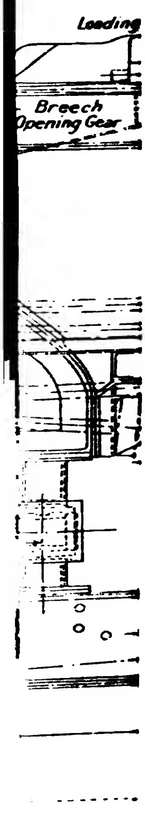
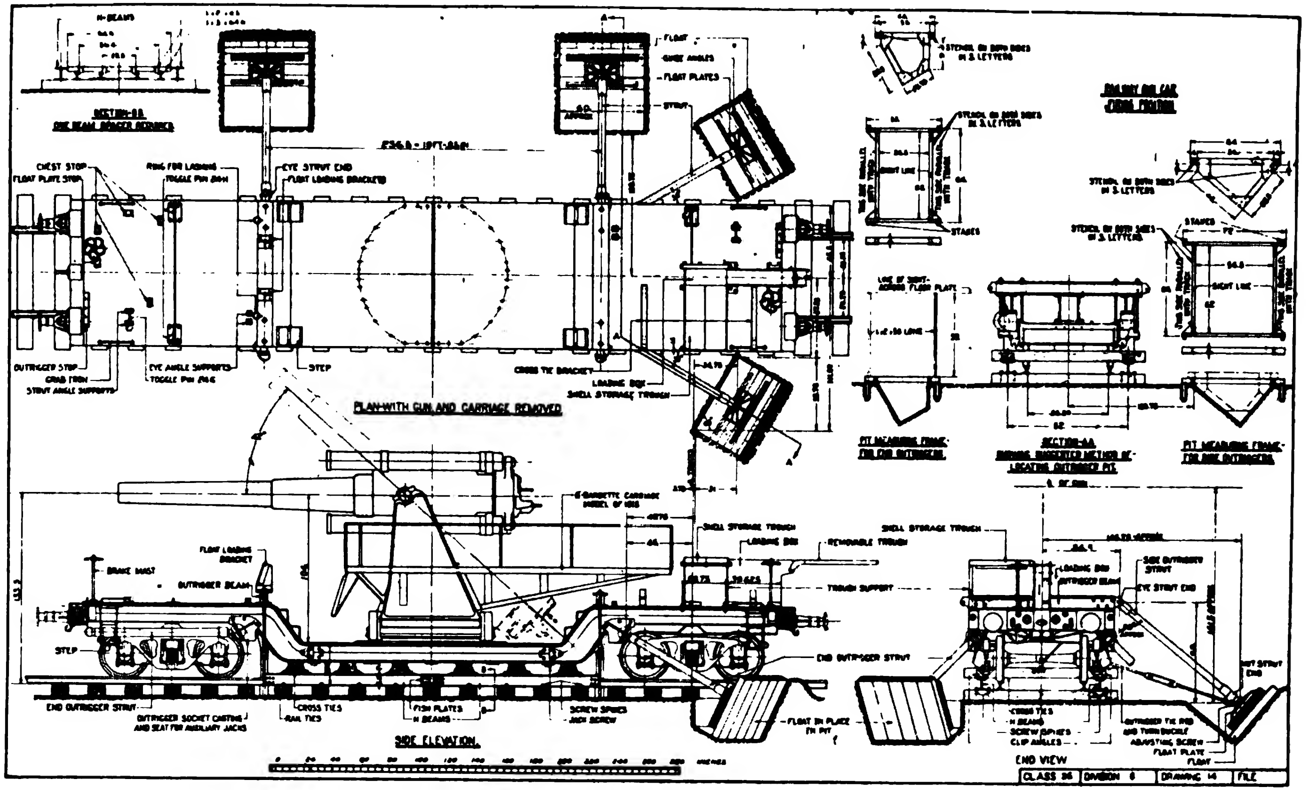


PLATE 30



RAILWAY MOUNT FOR AMERICAN 8-INCH GUN, 32-CALIBER.

PLATE 31

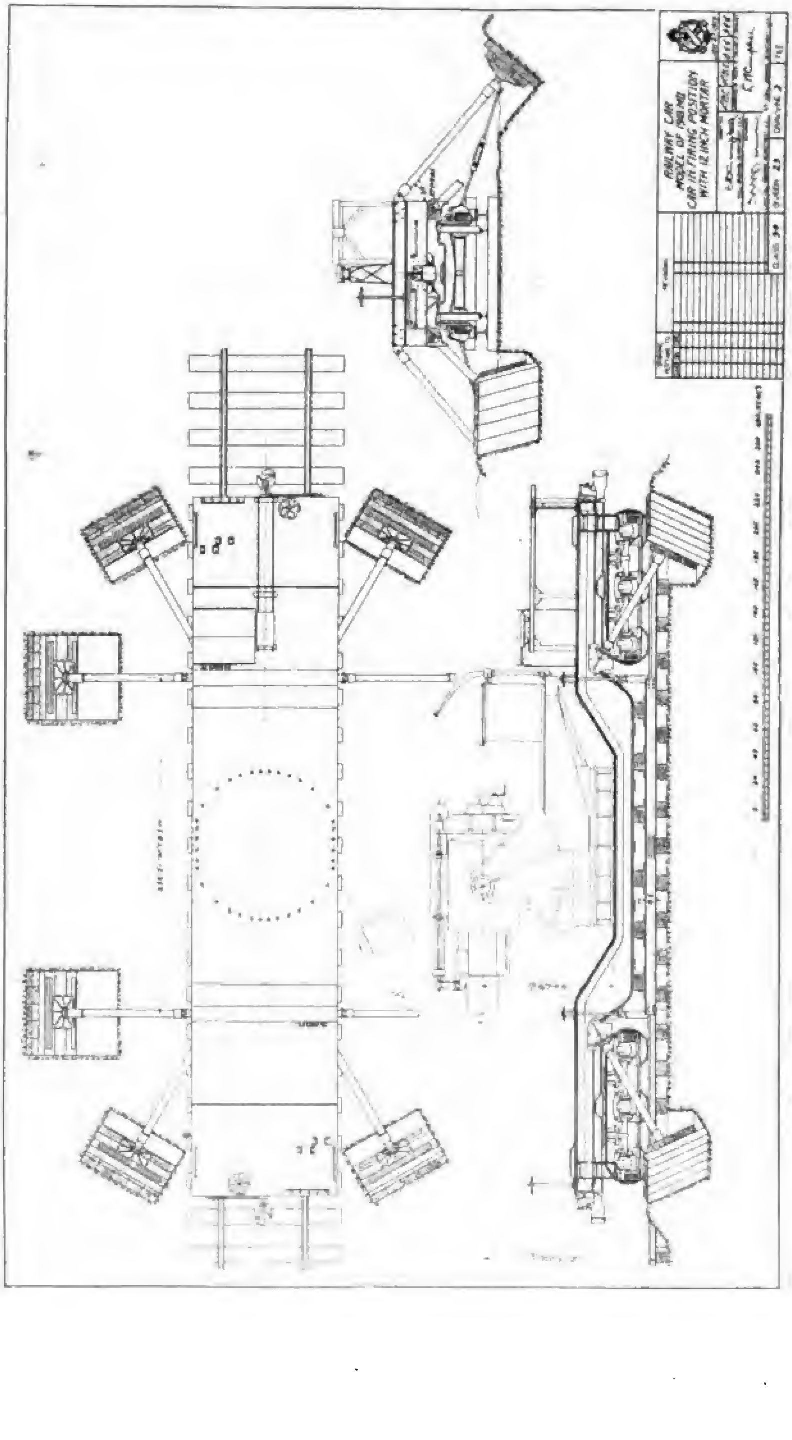
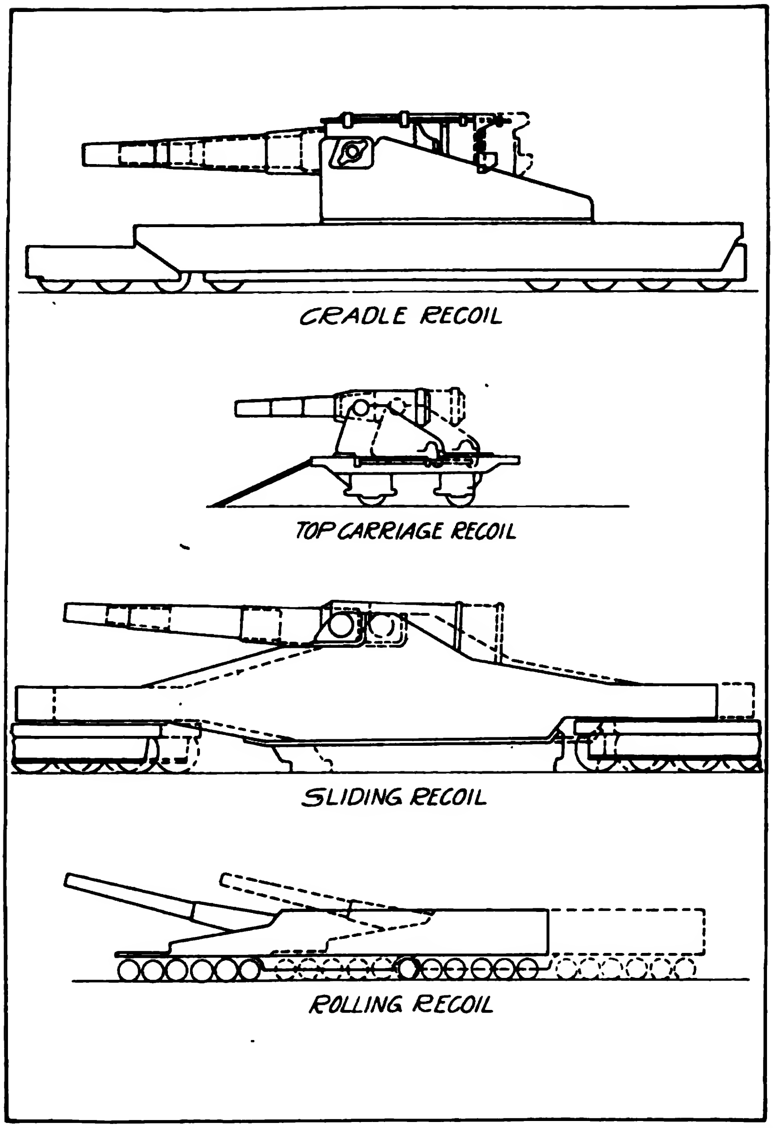


PLATE 32



CLASSIFICATION OF RAILWAY ARTILLERY ACCORDING TO RECOIL SYSTEMS.

are various but each is more or less characteristic of one of the above types and they will be described in detail under the appropriate heads.

25. CRADLE RECOIL.—The characteristic of this type is that the gun only recoils, moving backward along the line of fire, in a sleeve or cradle. The gun is retarded and brought to rest by means of hydraulic buffers, or dashpots, attached to the cradle, and with pistons which are rigidly attached to the gun. Return to battery is obtained by helical steel springs, or by the pressure of air in a pneumatic recuperator cylinder, in which increased compression is produced by the recoil. The cradle is provided with trunnions and the cradle and gun are swung in the trunnion bearings of the carriage. For examples of this type of recoil system see plates 33, 34, 35 (spring counterrecoil) and plates 36, 37, and 38 (pneumatic counterrecoil).

26. TOP-CARRIAGE RECOIL.—The characteristic of this type is that the gun is carried in a top carriage, supported by wheels on fixed rails. The gun and carriage recoil together in a fixed direction along these rails. Recoil is restrained by hydraulic buffers and return to battery is obtained either by gravity, through the use of inclined rails, up which the gun recoils, by springs, or on some improvised mounts, by rubber bands. An air recuperator might equally well be used, but no example of such a combination is known. Examples of this type with gravity counterrecoil are shown on plates 16 and 39, and with springs or rubber bands on plates 40 and 41.

27. SLIDING RECOIL.—The characteristics of this type are that the gun, car body, and trucks recoil together, the car body sliding on a special set of girders incorporated in the track. The car body is provided with wooden crossbeams or "sleepers" which are jacked down on the track girders in such a way that about one-half the weight of the mount is transferred to them from the truck. The resulting friction thus created absorbs the energy of recoil and brings the mount to rest. This recoil varies from 1 to 2 meters. All of these mounts, with two exceptions—the American Army 14-inch design and Italian 381-millimeter—are of the nontraversing type and must be fired from a previously prepared curved firing track or epi. Counter-recoil, or the return of the gun to firing position, is obtained by jacking up the sleepers, thus returning all of the weight to the trucks and rolling the entire mount forward by the amount of the recoil. This is usually accomplished by gear trains and handwheels, through which two or more pairs of wheels may be driven and exact adjustment of the mount on the track obtained. In the heavier mounts an electric motor drive is employed, and in other cases a gasoline winch has been used with success. Even with the heaviest guns ordinary car pushers, applied in sufficient number, have served as an emergency method of moving the gun back into battery. Examples of this type of mount may be found in a wide variety of calibers on plates 12, 13, 42, 43, and 44.

PLATE 33

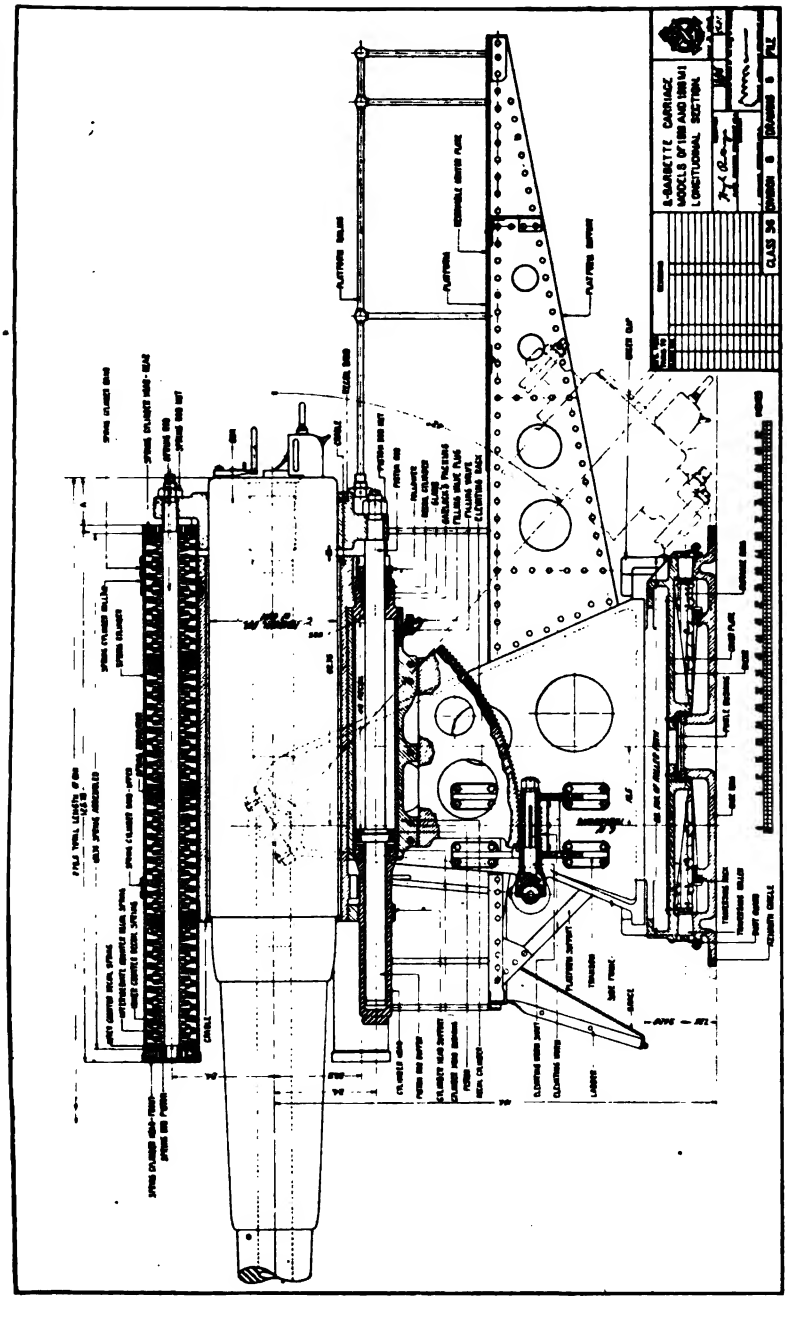


PLATE 34

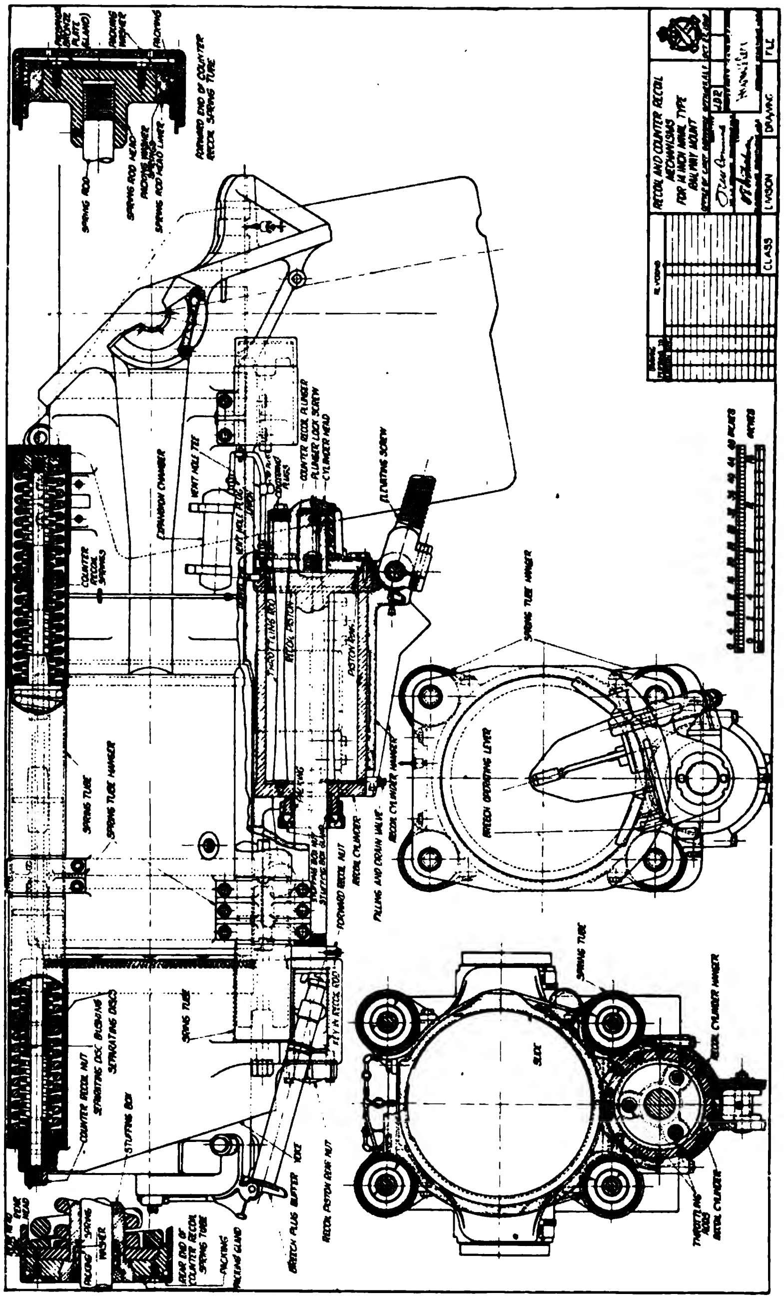

RECOIL AND COUNTER RECOIL MECHANISMS FOR 14 INCH NAVAL TYPE RAILWAY MOUNT
SPRING TUBE
SPRING TUBE HANGER
COUNTER RECOIL SPRINGS
EXPANSION CHAMBER
ELEVATING SCREW
BREECH OPERATING LEVER
SLIDE
RECOIL CYLINDER
RECOIL CYLINDER HANGER
STUFFING BOX
YOKE
BREECH PLUG BUFFER
RECOIL PISTON ROD NUT
FILLING AND DRAIN VALVE
FORWARD RECOIL NUT
COUNTER RECOIL NUT
SEPARATING DISC
SPRING ROD
FORWARD END OF COUNTER RECOIL SPRING TUBE
REAR END OF COUNTER RECOIL SPRING TUBE
PACKING GLAND
THROTTLING RODS

PLATE 35

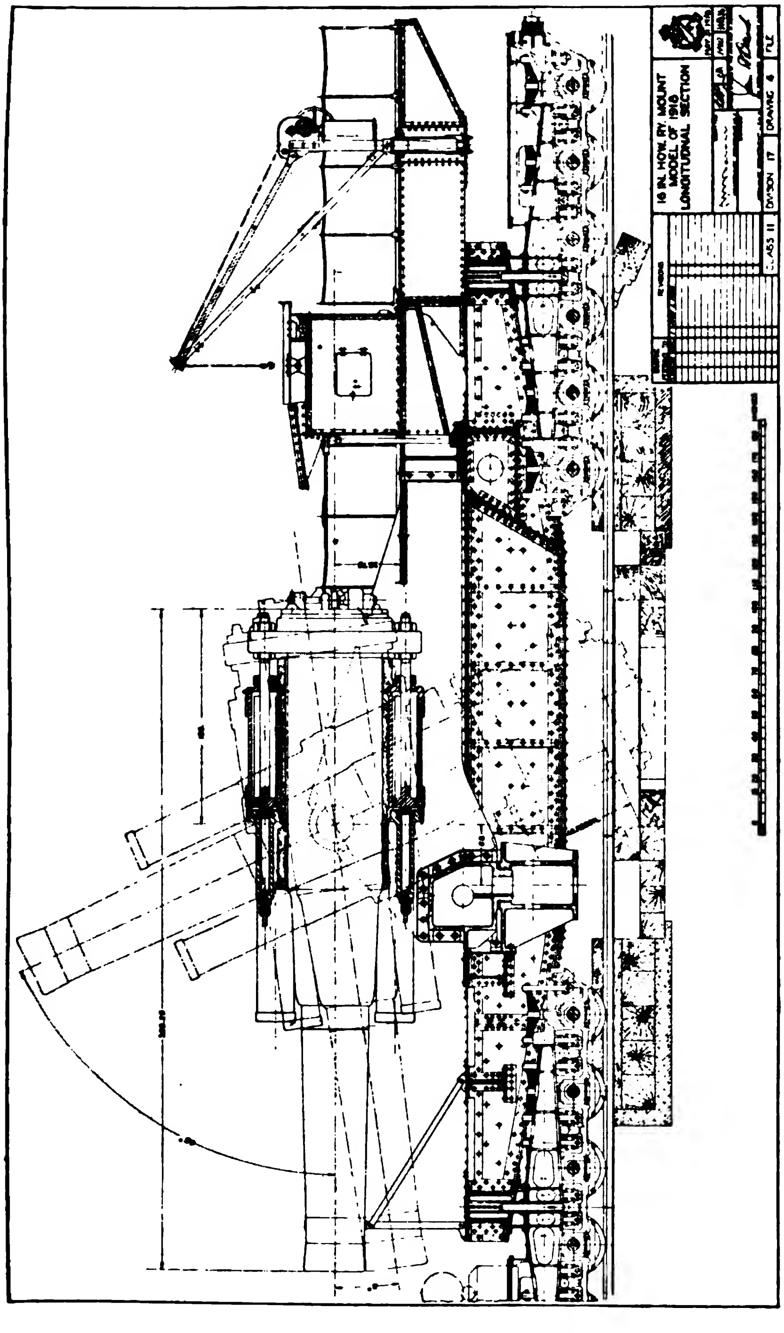
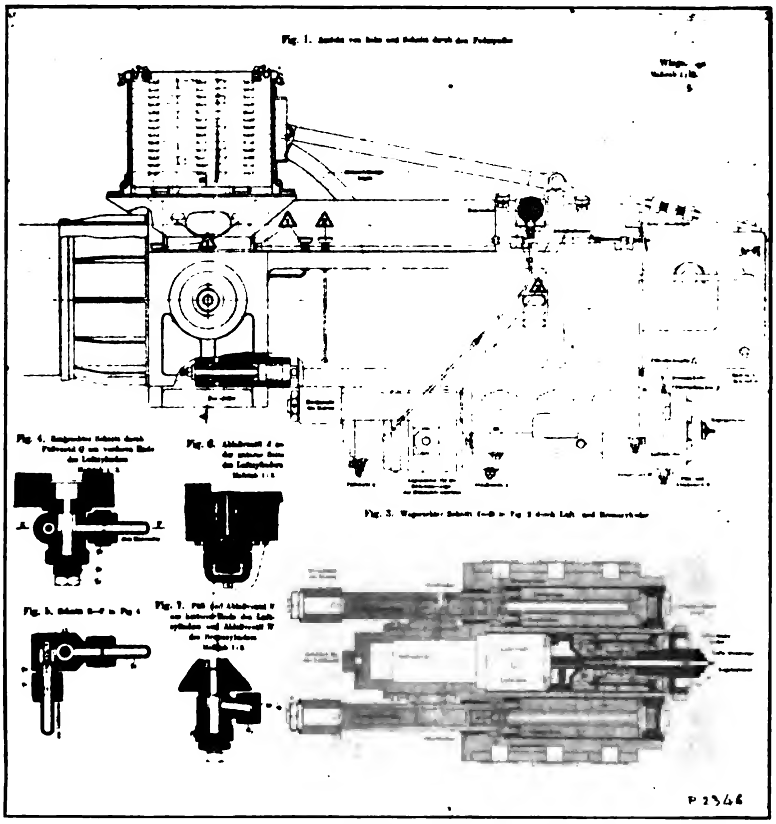

16 IN. HOW. RY. MOUNT
MODEL OF 1918
LONGITUDINAL SECTION
CLASS 11
DIVISION 17
DRAWING 4
FILE

PLATE 36



CRADLE RECOIL (HYDRO-PNEUMATIC) SYSTEM OF THE GERMAN 280-MM. GUN.

PLATE 37

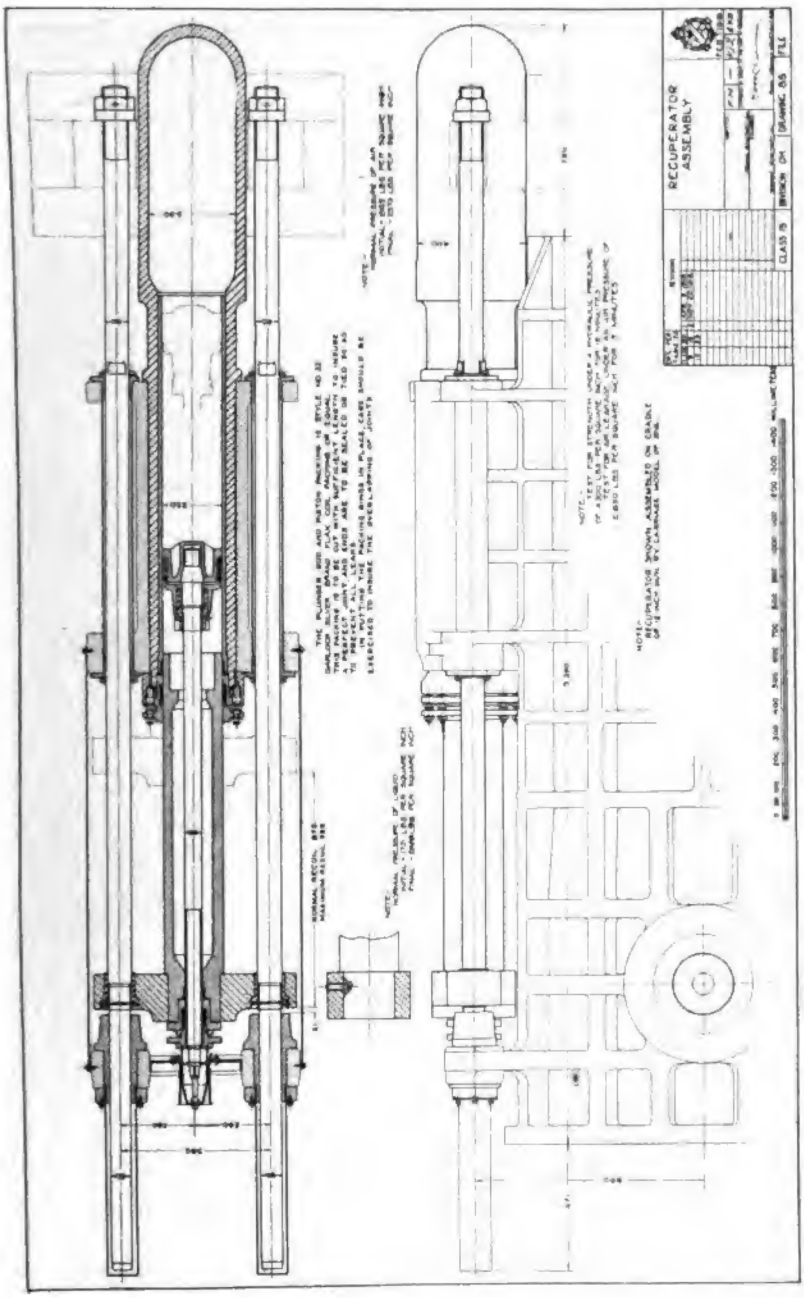


PLATE 38

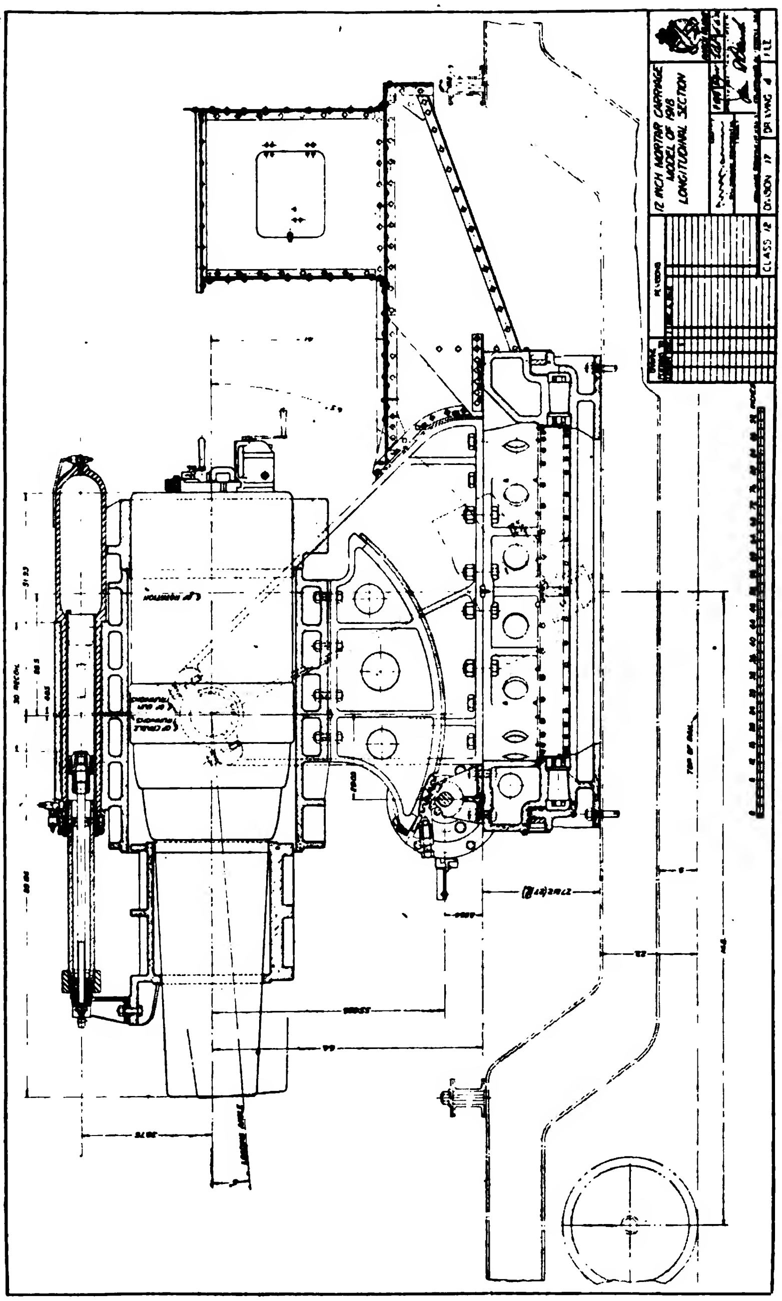
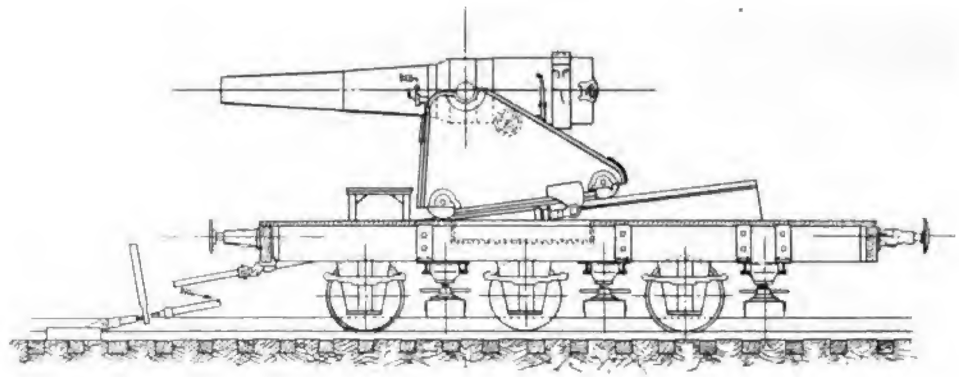

12 INCH MORTAR CARRIAGE
MODEL OF 1918
LONGITUDINAL SECTION

PLATE 39



TOP CARRIAGE RECOIL (HYDRO-GRAVITY) SYSTEM OF THE 190-MM. FRENCH HOWITZER.

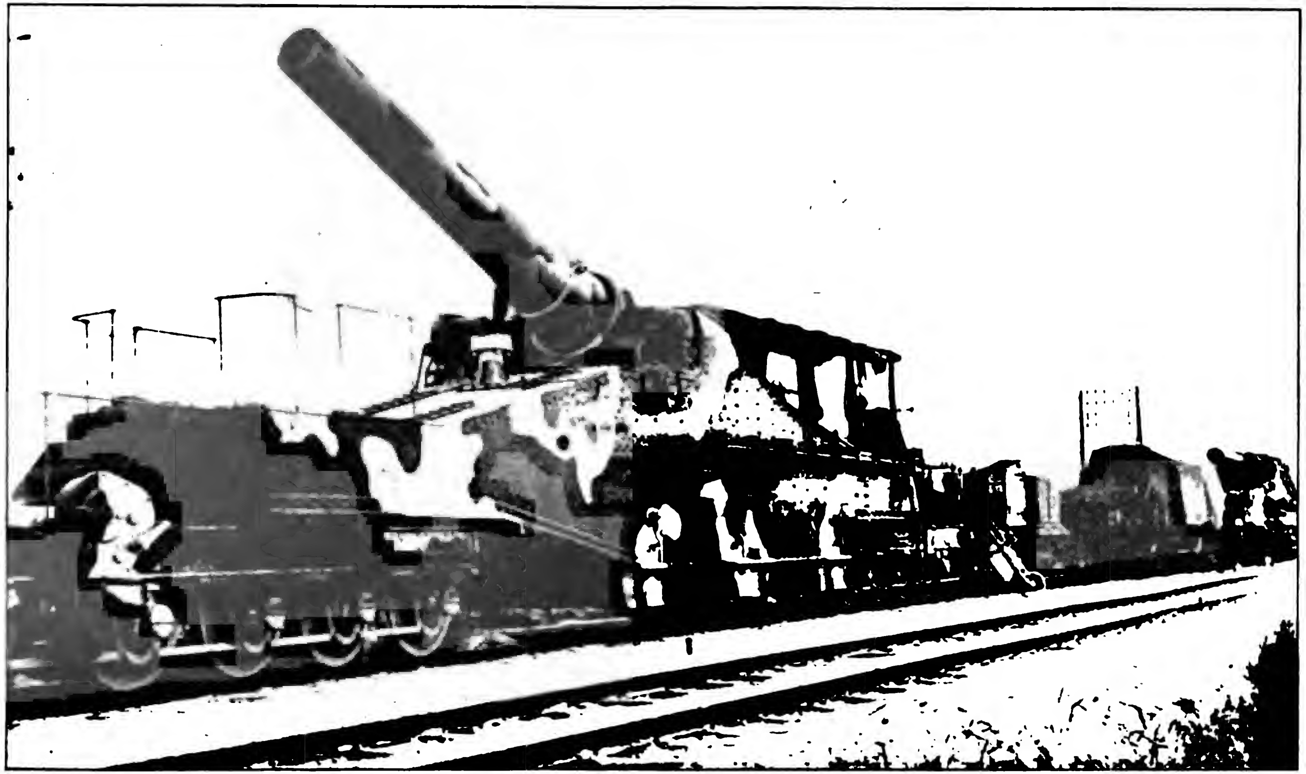
PLATE 40

TOP CARRIAGE RECOIL (RUBBER BAND RECUPERATORS) SYSTEM OF THE 190-MM. FRENCH HOWITZER.

PLATE 41

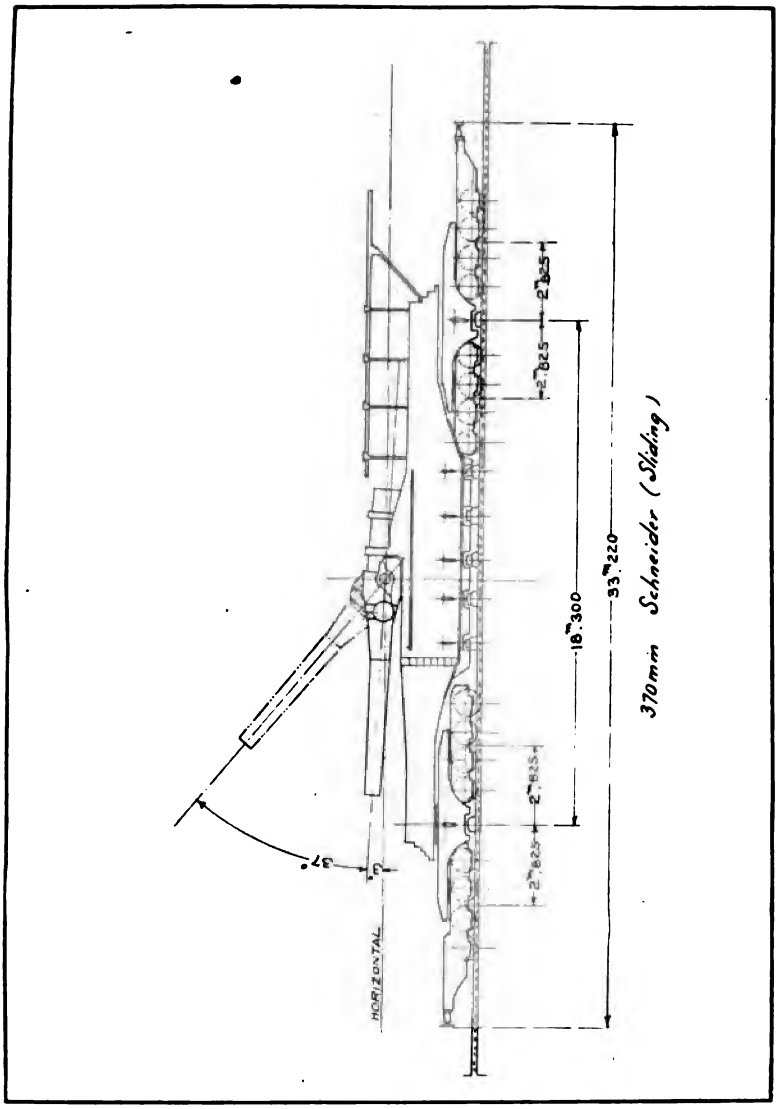
TOP CARRIAGE RECOIL (RUBBER BAND RECUPERATOR) OF THE FRENCH 240-MM. HOWITZER.

PLATE 42



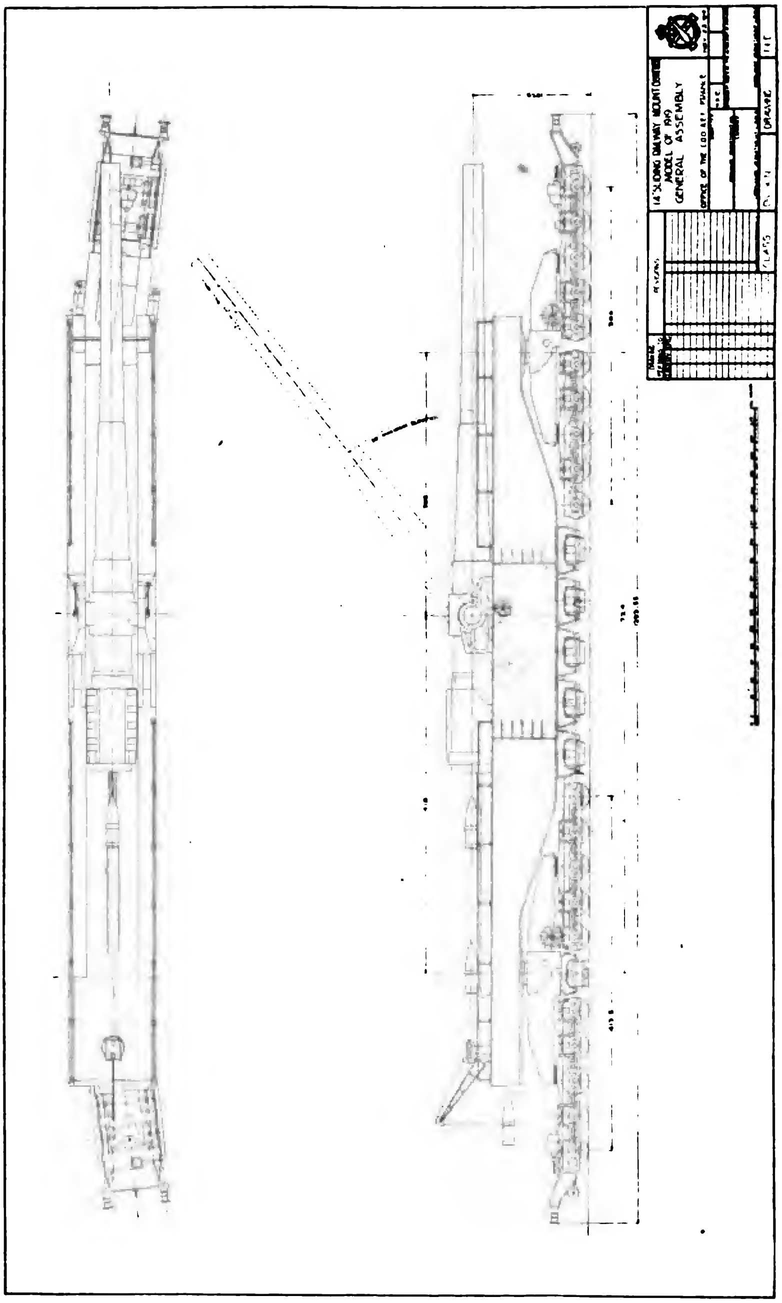
SLIDING TYPE MOUNT FOR FRENCH 320-MM. HOWITZER.

PLATE 43



370mm Schneider (Sliding)

PLATE 44


14" SLIDING RAILWAY MOUNT
MODEL OF 1919
GENERAL ASSEMBLY
CLASS

28. Rolling Recoil.—The characteristics of this type are that the gun, car body, and trucks recoil together, rolling backward on standard track, the brakes being set to bring the mount to rest. Return to battery is obtained by a winch mounted on the forward truck; the cable is attached to the track some distance ahead. Mounts of this type recoil a distance of from 30 to 50 feet. The use of this type of recoil alone is not practicable, as the vertical component of the force of recoil would be too great for the truck springs to stand. In all existing types the gun is mounted in a cradle, thereby giving a double recoil system. This type of mount is usually provided with car traverse, giving a small amount of movement in azimuth, and must, of course, be fired from a curved track to get a greater movement. Plates 20, 21, and 45 show examples of this type of recoil system in combination with a cradle as noted above.

29. Combinations.—These various systems are found in several combinations, also, in existing mounts.

Cradle-sliding recoil is found in the Schneider 520-millimeter howitzer, plate 46.

Cradle-rolling recoil is found in the British 12 and 14 inch rifle mounts and the United States Navy 14-inch mount, Mark II, plate 45.

Top-carriage-sliding recoil is found in the Schneider 270-millimeter howitzer as shown on plate 47.

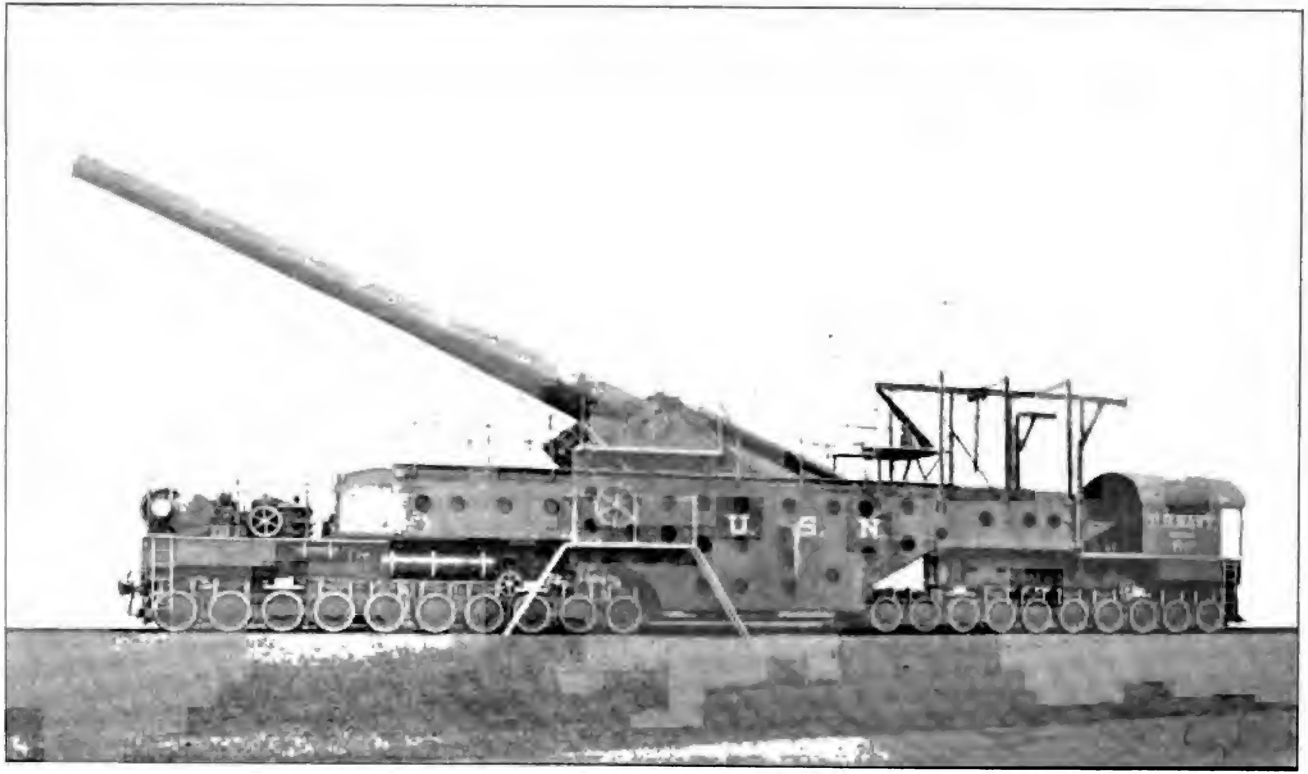
30. Discussion.—Cradle recoil with air recuperation is probably the highest development in recoil systems.

31. Top-carriage recoil was devised 40 or more years ago for coast defense guns operated at low angles of elevation. It is not well suited to firing at high elevations. This system is found only on railroad mounts which have been improvised from available coast defense matériel, and there seems no great reason why it should be considered for new design.

32. The sliding recoil system is worthy of considerable consideration. Improvised originally to provide for heavy guns, a mount which could be manufactured in a minimum of time, it has shown a ruggedness and convenience in service that have recommended it very highly. There are certain limitations on the use of this type of mount. Time of operation and lack of traverse make it unsuited to small guns. The enormous trunnion forces which must be taken care of likewise make it unsuited for the very largest howitzers firing at high angles.

33. The cradle-rolling recoil combination is, like the sliding system, unsuited to small guns, because of the lack of traverse and time of operation, but it represents a very satisfactory system for the heaviest type of guns.

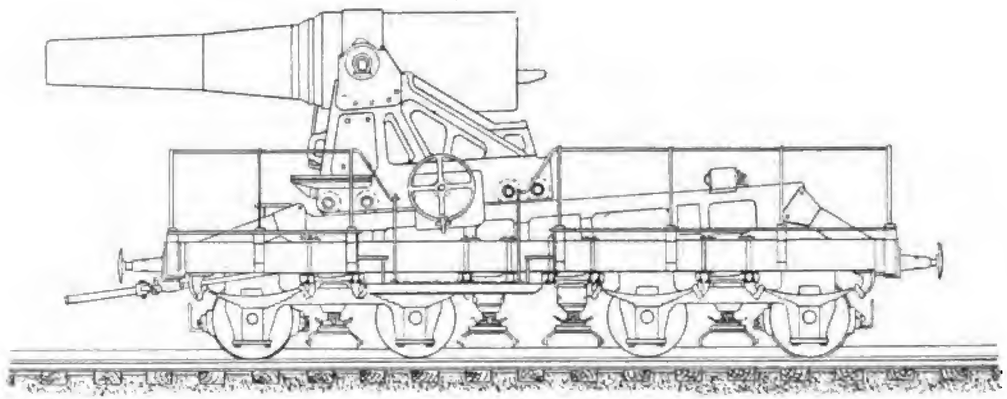
PLATE 45



ROLLING RECOIL MOUNT, MARK II, FOR AMERICAN NAVY, 14-INCH, 50-CALIBER GUN.

CRADLE SLIDING RECOIL MOUNT FOR FRENCH 520-MM. HOWITZER.

Plate 47



TOP CARRIAGE SLIDING MOUNT FOR FRENCH 274-MM. HOWITZER.

CLASSIFICATION ACCORDING TO METHOD OF ANCHORAGE.

34. Railway mounts may be classified according to the character of the structure required to transmit the force of recoil from the gun to the earth, as follows:

1. Mounts requiring no structure whatever.
2. Mounts requiring a track platform; i. e., a structure built above and more or less without disturbing the track.
3. Mounts requiring a ground platform; i. e., a structure fitting into and under the track.

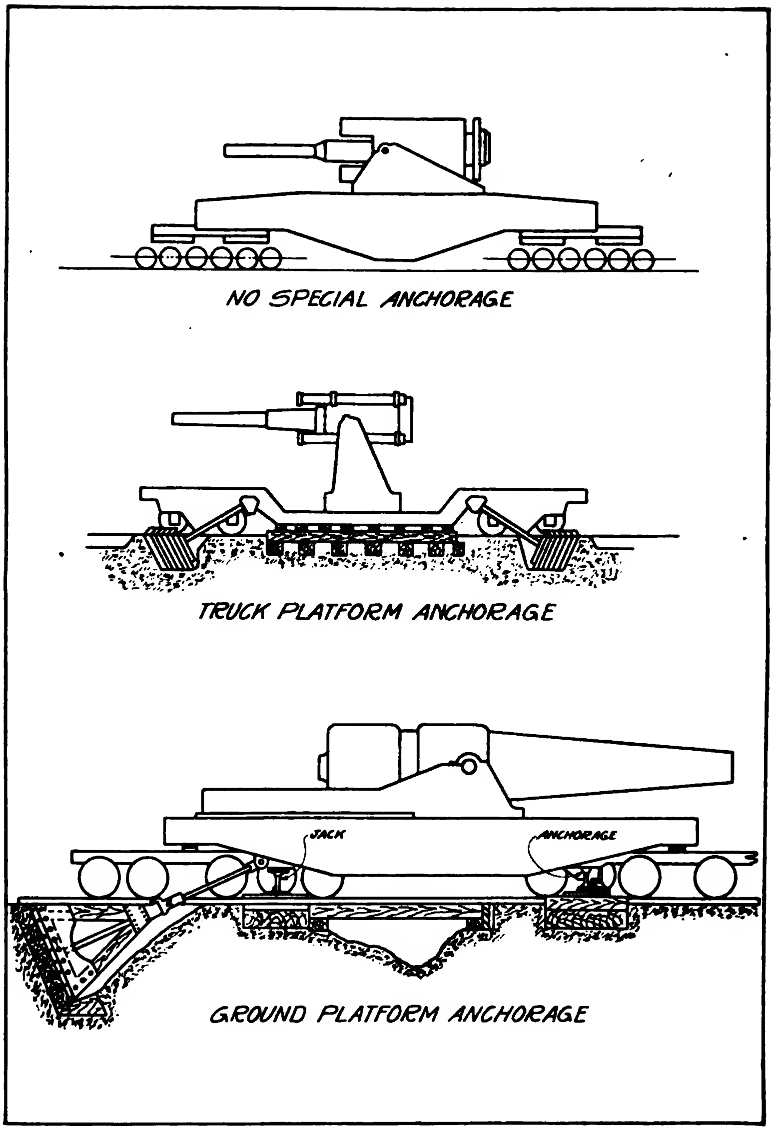
These schemes of anchorage are illustrated on plate 48.

35. Mounts Requiring no Structure.—The only mounts of this type are those with the combination of cradle and rolling recoil mechanism, which fire directly from standard track. They are provided with car-body traverse, giving a small movement in azimuth, and must be fired from a curved track or epi to get greater traverse. The British 12-inch and 14-inch rifle mounts, the American 14-inch naval mount, Mark I (for firing at angles under 15 degrees) and Mark II (for elevations as great as 40 degrees), the 16-inch howitzer, model 1918 MI (American), and German 38-centimeter are examples. These are shown on plates 20, 21, 45, and 364.

36. Mounts Requiring a Track Platform.—In mounts of this type a part of the vertical component of the force of recoil is taken by girders, pads, or floats placed on the ground or on top of the ties, and the horizontal component either by friction, or through rail clamps, guys, or struts. The Schneider sliding mounts are examples of the type in which the horizontal component is absorbed by friction. This type can have only very limited car traverse (a maximum of 5 degrees), since a greater traverse will result in an abnormal displacement of the track. They are shown on plates 12, 13, 42, 43, and 46. The 194 and 240 millimeter Schneider mounts and the British 12-inch howitzers and 9.2-inch guns belong to the class employing rail clamps or guys. They have top-carriage or cradle recoil and in some cases afford all-round fire. These are shown on plates 16, 41, 49, and 50. The American 8-inch gun, plate 30, and French 240-millimeter gun, plate 27, belong to the class using struts as well as track platforms and both permit of all-round fire.

37. Mounts Requiring a Ground Platform.—The characteristics of this type is that an extensive anchorage, the installation of which involves tearing up the track, must be constructed before firing can take place. This foundation may consist simply of very heavy timber pads and floats, as with the St. Chamond 340 and 400 millimeter and the American 16-inch mounts, or it may be a very elaborate and specially constructed steel or concrete base, as with the Batignolles, and the German 280 and 380 millimeter mounts.

PLATE 48



CLASSIFICATION OF RAILWAY ARTILLERY ACCORDING TO METHOD OF ANCHORAGE.

PLATE 40

HOLDFAST, RAILWAY TRUCK, MARK II.

SHOWING METHOD OF ATTACHMENT TO TRUCKS, RAILWAY, B.L. 12 INCH HOWITZERS, MARKS I & II.

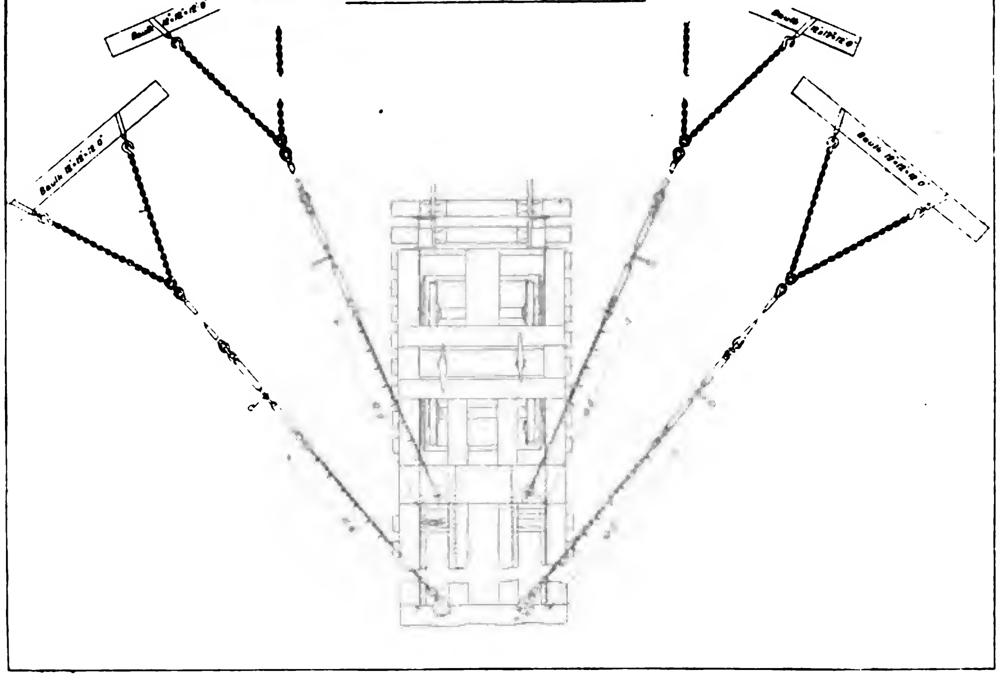
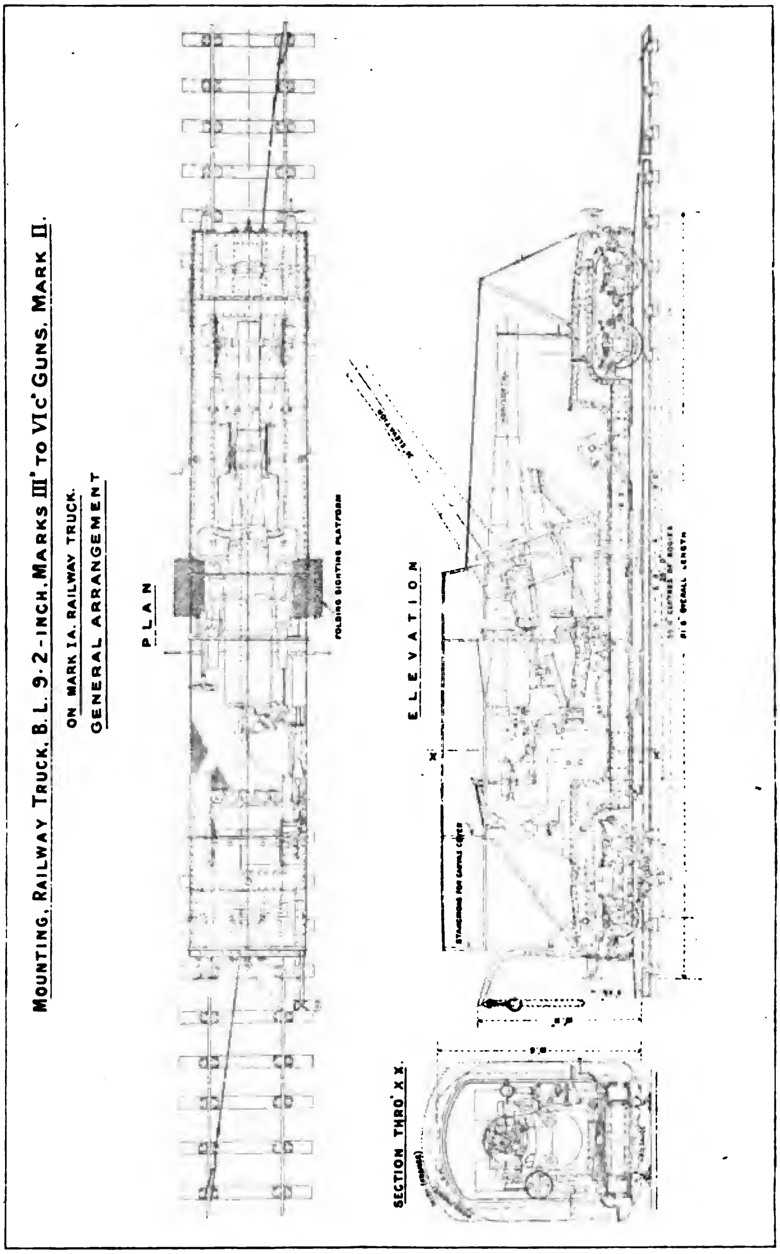


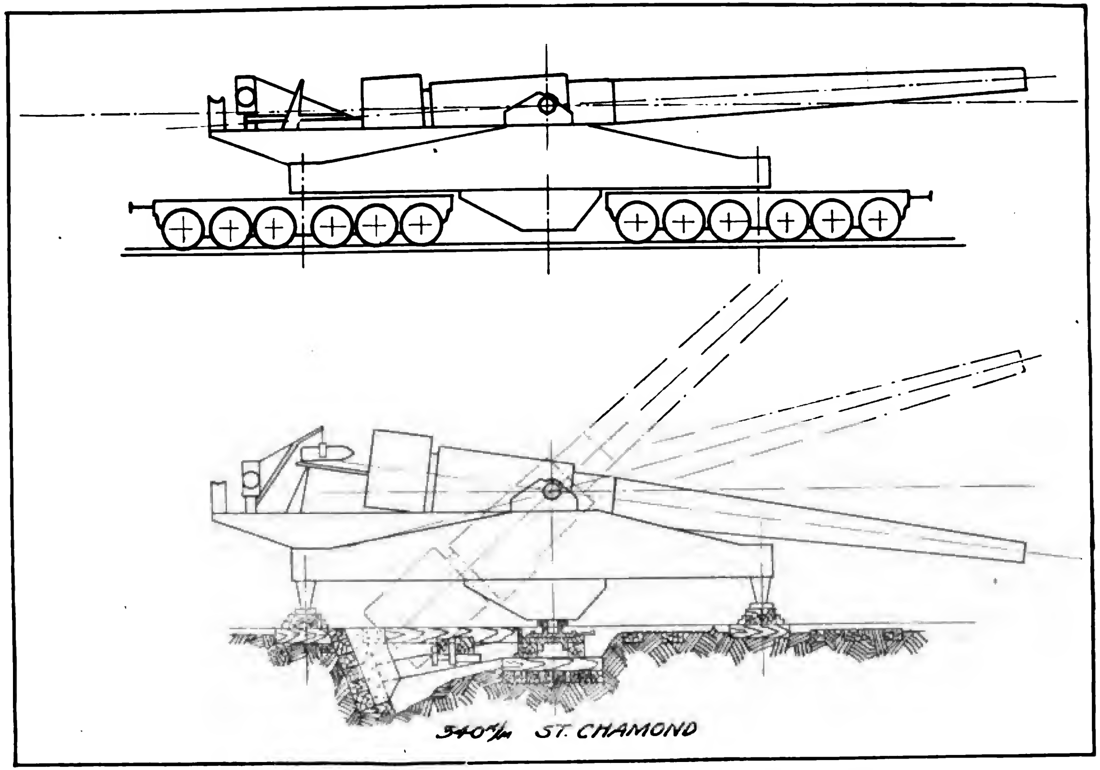
PLATE 50


MOUNTING, RAILWAY TRUCK, B.L. 9·2-INCH, MARKS III* TO VIc* GUNS, MARK II.
ON MARK I A. RAILWAY TRUCK.
GENERAL ARRANGEMENT
PLAN
FOLDING SIGHTING PLATFORM
ELEVATION
SECTION THRO' X X.

In almost all cases only a very limited traverse is possible. The German guns give all-round fire. The above noted mounts are illustrated on plates 51, 52, 53, 209, 54, 24, 55, 56, and 57.

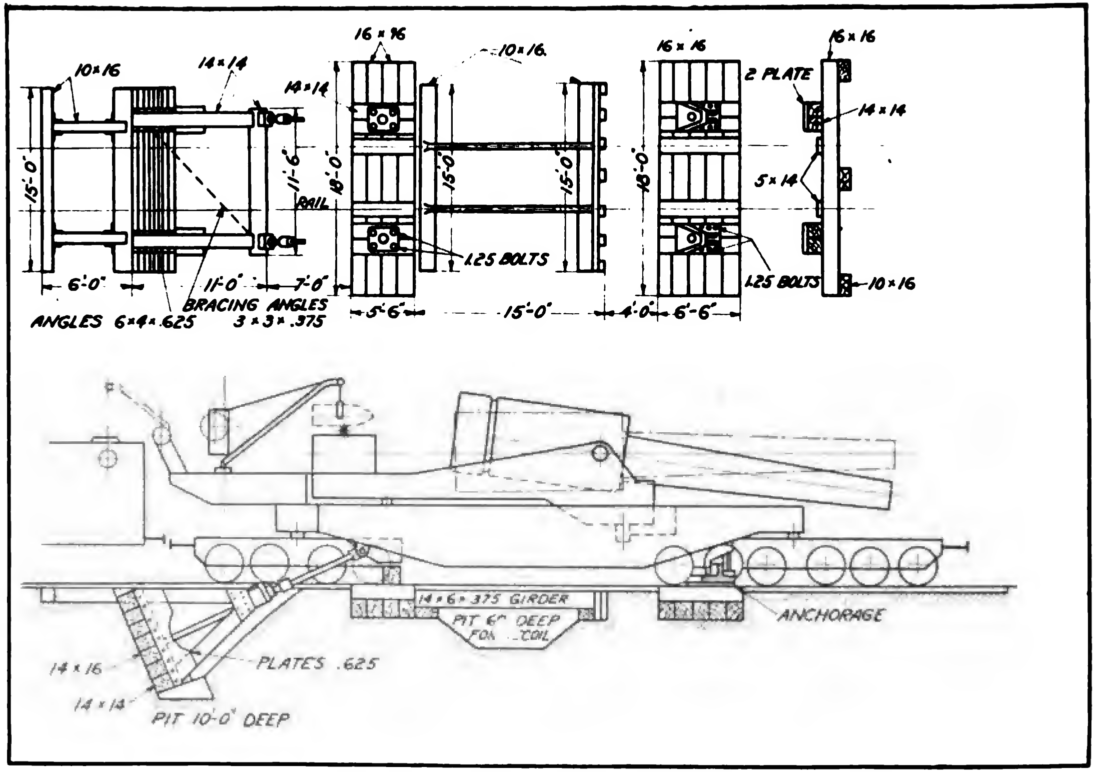
38. DISCUSSION.—Two points are intimately connected with the type of anchorage employed, viz: (1) The time necessary to get into action and withdraw the mount from position, and (2) the amount of traverse allowed. The former is important in effecting a surprise and in withdrawing to avoid enemy counterfire. It varies from almost nothing on the first type, after the epi is constructed, to perhaps an hour on the best of the second type, and then up to three or four days on the very elaborate mounts of the ground platform type. As to traverse, the first type permits any desired amount, limited only by the extent of the curve, and is suited to the largest calibers; the second likewise permits of a traverse limited only by the extent of the curve for heavy guns with sliding recoil and all-round fire for the lighter and medium guns. The third type usually permits of only limited traverse (10 to 15 degrees) for the heaviest guns and all-round fire for medium calibers. It might be added that rail clamps and guys are devices adopted with the lighter guns and are to be considered improvisations; struts have proved more efficient.

PLATE 51



METHOD OF ANCHORING 340-MM. FRENCH GUN RAILWAY MOUNT.

PLATE 52



METHOD OF ANCHORING 400-MM. FRENCH HOWITZER RAILWAY MOUNT.

PLATE 53

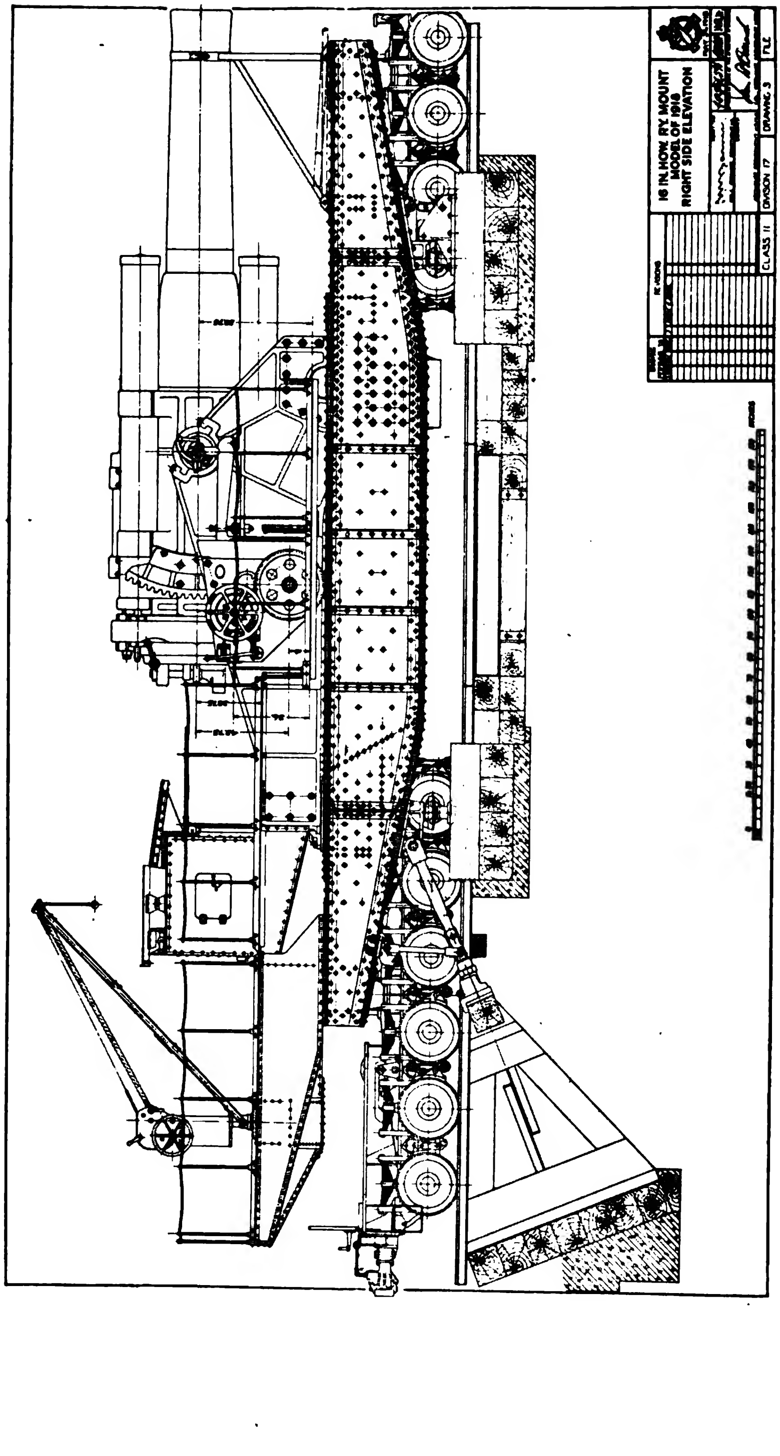

16 IN. HOW. RY. MOUNT
MODEL OF 1918
RIGHT SIDE ELEVATION
CLASS 11
DIVISION 17
DRAWING 3

PLATE 54

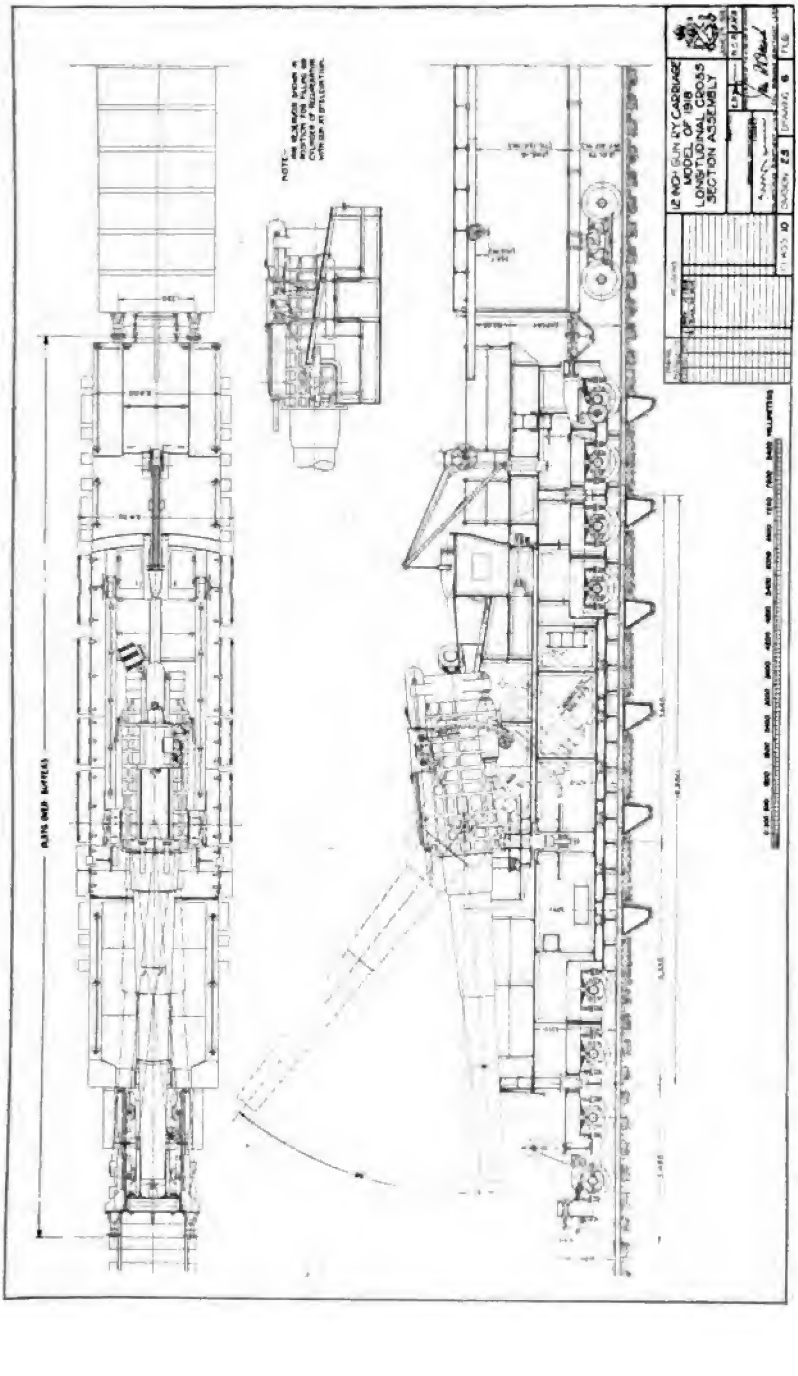
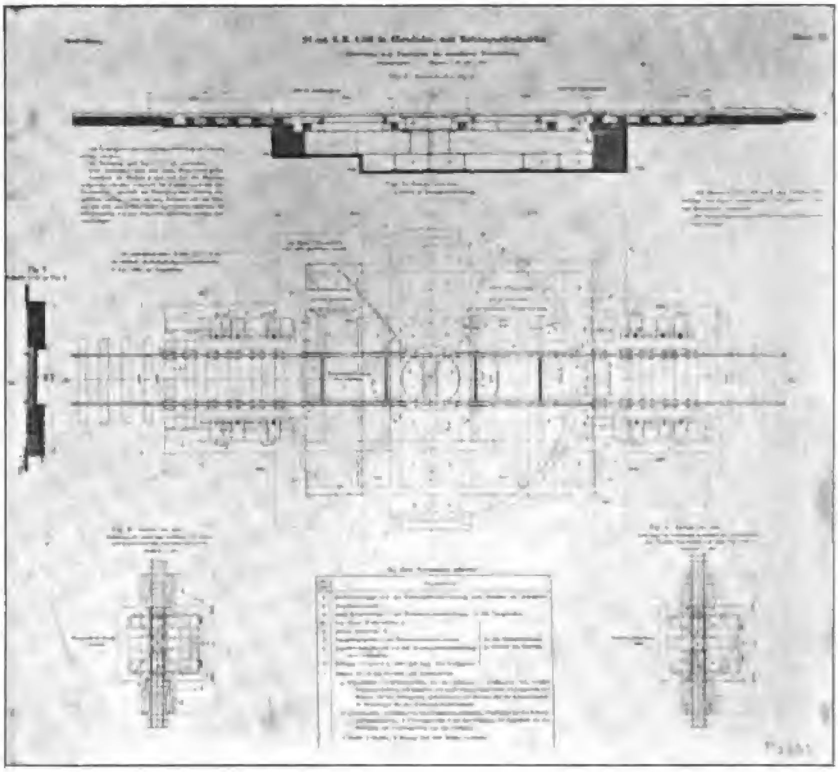
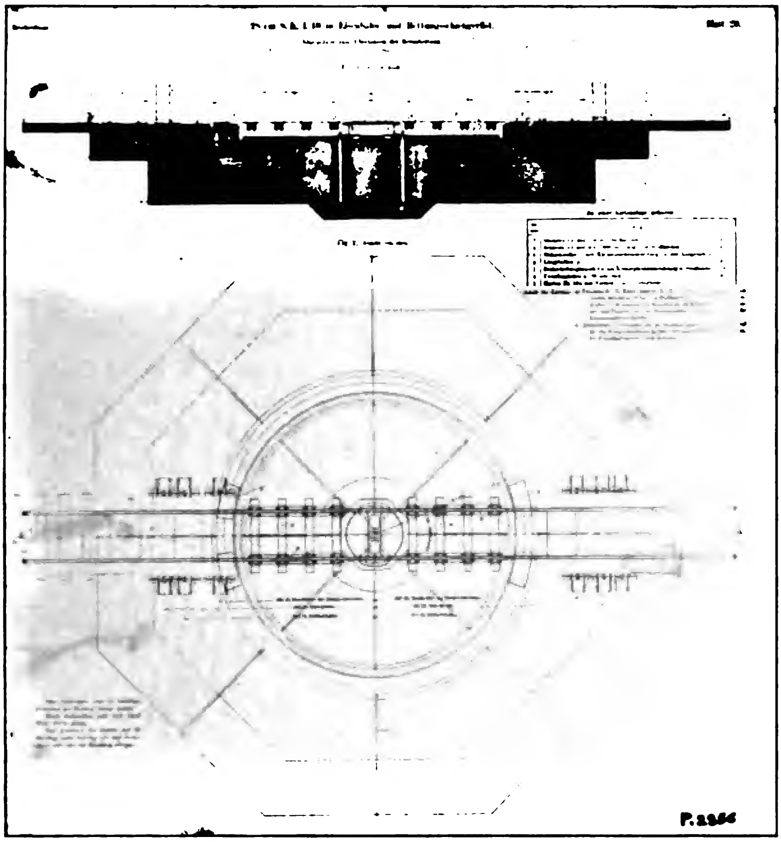

12 INCH GUN RY CARRIAGE
MODEL OF 1918
LONGITUDINAL CROSS
SECTION ASSEMBLY

PLATE 55



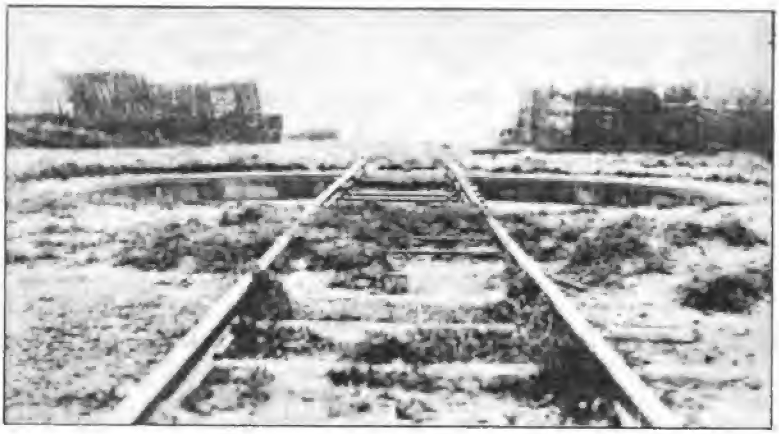
STRUCTURAL STEEL EMPLACEMENT FOR 280-MM. GUN.

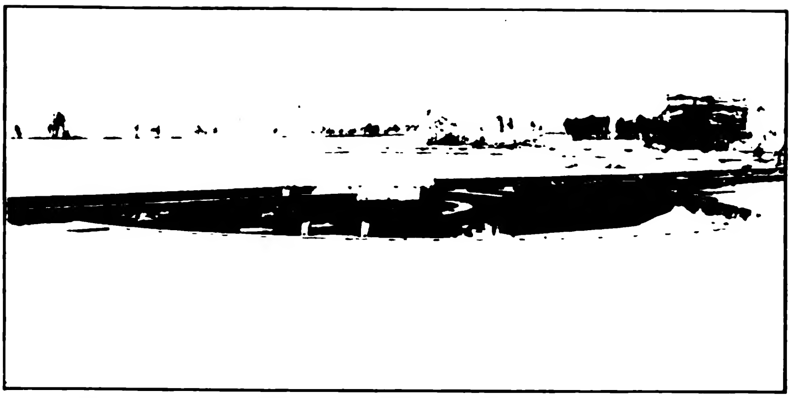
PLATE 56



CONCRETE EMPLACEMENT FOR GERMAN 280-MM. GUN.

PLATE 57





CONCRETE EMPLACEMENTS FOR GERMAN 280-MM. GUN RAILWAY MOUNTS ON THE COAST OF BELGIUM.

SECTION 2.

SCOPE OF UTILITY OF RAILWAY ARTILLERY.

39. Experience with railway artillery in the present war has been almost entirely in land warfare, so that the following is written primarily to cover that field. A final paragraph is added, however, covering its use for coast defense.

40. In considering the scope of utility of railway artillery in land warfare, several general limitations should be borne in mind. It is the heaviest, most powerful, and most costly of all artillery and for this reason, it should be exposed to a minimum of danger of destruction and capture, and should be used only when heavy mobile artillery will not suffice. It is hence used only for offensive operations and special service, being organized as a separate reserve and not attached to any one army. Except in sectors of a front, which have been quiet for a long while, standard gauge railway lines can not easily be maintained closer than from 5 to 10 kilometers to the line, hence heavy railway artillery can not be operated closer to the line. Further, experience has taught that it should be kept out of the range of the field guns and smaller caliber heavy guns. In some cases, as in the American St. Mihiel offensive of September, 1918, the railway artillery was run up to within 3 kilometers of the front lines. This point is discussed more fully in section 7.

41. Within the limitations noted above, railway artillery is utilized for the following purposes:

Destruction.
Counter-battery work.
Interdiction.
Distant bombardment for moral effect.

42. Destruction.—Fire of destruction as executed by railway artillery has for objectives in general order of range:

(*a*) Permanently fortified works, as concrete turrets, observation posts, sentry towers or observation posts, concrete rampart shelters, concrete cantonment shelters, gun casemates, flanking casemates, and flank trenches, concrete communication galleries, troop shelters, machine gun and antitank forts.

(*b*) Bridges, culverts, cuts, and fills.

(*c*) Balloons and towers used for observation and located at long range.

(*d*) Centers of supply and distribution, as railroad yards, supply depots, ammunition dumps, industrial centers, etc.

Except in the case of (*c*) above, it is obvious that, for the purpose of destruction the maximum plunging fire is desirable and that the pieces that should be used are howitzers and mortars, so long as the necessary range can be obtained with them. Objectives of class (*d*) are ordinarily located at such ranges that guns must be used, It is evident that relatively large explosive charges and perhaps numerous shots will be required for this purpose and, except in the last case, very high accuracy of fire is essential.

43. Counter-battery work.—Under the heading of counter-battery work is ordinarily included the destruction of only such enemy batteries as are so distant as to be beyond the range, or so well protected as to be beyond the destructive power of the army artillery. Occasionally it may be imperative that certain batteries be put out of action in much less time than would be possible with army artillery that must be moved up from some other locality. In these cases, obviously, railway artillery capable of all-round fire should be used.

44. Circumstances demand ordinarily cannon of long range and medium caliber for this work and mounts provided with facilities for the most rapid and universal service: This would include mounts whose firing platform requires a very small time for installation, and mounts provided with traverse for all-round or nearly all-round fire.

45. Interdiction.—The objectives of fire of interdiction are lines of communication, roads, railroads, telegraph, and telephone lines, etc. It may be very desirable to keep a section of a certain railway line out of commission. It may be desirable likewise to shell certain sections of very important roads over which supplies and men must be moved. At night a few shells per hour may be sufficient to seriously interrupt traffic. During the day when observation is possible more active shelling may be carried out. Guns of long range, medium caliber, and large traverse are preferred for this work. The practice has been to carry out fire of interdiction only when it will be most effective, i. e., immediately before, during, or immediately after, an attack.

46. Distant Bombardment for Moral Effect.—The objectives of bombardment for moral effect are large centers of population long distances behind the lines. The aim is to destroy any sense of security which the distance from the front lines may give the civilian, to undermine the spirit of the army by weakening the morale of the civil population, and to interfere to the maximum with the administration of the war.

47. The characteristic of first importance for this kind of fire is extremely long range, 100 to 120 kilometers or so. Difficulties of construction seem to limit the caliber of these long guns to about 240 millimeters. Little or no traverse is required. At least one shot per

hour is considered necessary to produce the desired effect, and absolute regularity in the bombardment is necessary for the maximum effect on morale.

48. The single example of action from a gun of this sort was the bombardment of Paris. The writer was in Paris for several days at a time on four occasions during the bombardment by the long-range gun. On some days projectiles arrived every 15 minutes from about 8 a. m. to 5 p. m. On other days the bombardment would begin promptly at 12.40 noon. On the first day of the bombardment, on March 23, 1918, there was considerable confusion, more because the people thought they were being bombed by airplanes from a great height than from any other apparent reason. From then on the effect could not be determined with any certainty. There seemed to be as many people on the streets during the days of most active bombardment as on quiet days. When a projectile would burst the people in that vicinity would appear startled but not frightened and always some would hurry in the direction of the explosion to see the damage. All of the trains going west or south from Paris were crowded in those days, but there was no evidence that the departure of those people who lived in Paris was not caused by the steady approach of the Germans and the possibility of the capture of Paris rather than through panic or fear of the bombardment.

49. The damage done by the long-range projectiles was never very great. If one burst in a building its effect was not always evident outside. One shell hole seen in the Gardens of the Tuilleries was about 4 feet deep and from 10 to 12 feet in diameter. Further, the dispersion of the guns was so great that two projectiles would land within a kilometer of each other only by chance. Judging from the small extent of damage and the doubtful effect produced on the civil population, it would seem extremely doubtful if such bombardment as this is nearly as effective either from the standpoint of material damage or effect on morale, as an equal investment in bombing planes and bombs. A published statement of the work of aeroplanes and of the long-range guns is given as an appendix to this report.

50. Assignment of Mounts to Various Duties.—The following rules govern the assignment of types of railway artillery to the various duties detailed above.

(*a*) Calibers of pieces are assigned according to the resistance of the targets.

(*b*) Types of pieces (mortar, howitzer, rifle) are assigned according to range (see later discussion).

(*c*) Types of mounts (as regards provision for traverse, anchorage, etc.) are assigned according to the number of different targets to be fired upon and the time available for preparation and change of position.

Following is a discussion of the significance of each of the above rules.

51. ASSIGNMENT OF CALIBERS ACCORDING TO RESISTANCE OF TARGETS.—Railway artillery is far too difficult to manufacture and too valuable to be used except at the nearest possible approach to a 100 per cent efficiency basis. It would be most unwise to undertake to destroy certain heavy concrete fortifications with 194-millimeter howitzers, involving the expenditure of a great amount of ammunition and considerable wear of the guns and perhaps, after all, not accomplishing satisfactory results, when a few shells from a 320-millimeter howitzer would accomplish the desired results. Further, it would be criminal to use 320-millimeter howitzers on machine-gun forts, sentry towers, etc., if smaller howitzers were available.

52. In the region northeast of Soissons the Germans were using in 1917 some old quarries very similar to a series of mine galleries, some 90 feet or more under ground, as troop shelters. The French were aware of this fact, and in preparing for their offensive in this region, decided to attempt the destruction of these shelters. 400-millimeter howitzers were assigned to the work, and with their great weight of projectile, high angle of fire, and consequent nearly vertical drop of projectile, accomplished very satisfactory results. The shells penetrated the overlying earth and chalk to a depth of about 50 feet and on bursting caused great sections of the roofs of the galleries to drop, imprisoning or killing the Germans.

53. ASSIGNMENT OF TYPES ACCORDING TO RANGE.—As with resistance of target so with range, no more powerful gun should be employed than is absolutely necessary. Wear, first cost, and time of manufacture are all much less on the shorter and less powerful guns. The following table, which is taken from French experience, shows clearly the relative rates of wear at the various ranges. It is evident that to use a 300-round gun on objectives that could be destroyed as effectively by from 2,000 to 4,000 round howitzers would be nothing short of criminal.

Gun.	Caliber length.	Range.	Life, rounds.
280-millimeter howitzer	15	11,490	4,000
24-G howitzer	20	13,700	3,000
240-millimeter T. R. 1903	27	16,800	2,400
240-millimeter model 1893-6	40	23,200	500
305-millimeter model 1893-6	40	27,000	300

In regard to the other two points, cost and time of manufacture, only about half the time is required to manufacture a howitzer as to make a gun of the same caliber, lighter machinery may be employed, and the cost is even less than half.

54. Relative Wear of Guns.—The accuracy life of any gun is greatly increased if it is fired with reduced charges and consequently reduced muzzle velocities. The following British table of equivalent charges illustrates this point:

Equivalent charges, showing relative wear of guns with various charges.

[Full charge taken as 100 per cent wear.]

No. of parts of charge.	15-inch howitzer.	12-inch howitzer, I and II.	9.2-inch howitzer.	8-inch howitzer.	6-inch 26 cwt.	6-inch 30 cwt.	4.5-inch howitzer.
6	1.000	1.00	....	....	....	....	....
5	.62	.48	....	....	....	....	1.00
4	.38	.27	1.00	1.00	1.00	1.00	.22
3	.27	.14	.30	.14	.15	.24	.08
2	.17	.09	.17	.07	.07	.06	.05
1	.13	.06	.07	.04	.03	.03	.04

55. In view of these facts it would seem best to use the shortest gun and the lowest charge and muzzle velocity possible. The closest point at which it is possible safely to locate the piece determines, of course, the range. Ideal practice, therefore, would be to use the shortest piece of the required caliber, which at its most favorable elevation can realize this range. If the nearest piece to the ideal which is available has a range materially greater than that required, then it should be fired with as much of a reduced charge as possible.

56. In this connection it is, of course, understood that the designer and builder and the users of the gun will probably never agree on the question of their proper use. A prime and proper desire always in the mind of the user is for greater and greater range. The designer and builder dislikes to see his machine abused and wishes to keep the muzzle velocity as low as possible.

57. Assignment of Types of Mounts According to Time Available for Emplacement.—It is to be assumed, of course, that the caliber and type of gun required has first been determined in accordance with the resistance and range of the target. With any given type and caliber of gun there will ordinarily be found a series of mounts, some of which afford no traverse, others limited traverse, and still others all-round traverse. Some mounts require no anchorage, others require a simple arrangement which may be put in place in an hour or less, while others use very elaborate emplacements, requiring from two to five days to install. The principle upon which mounts having various characteristics as to traverse and extent of anchorage will be selected, is that the least valuable gun and mount that can be made to satisfactorily accomplish the desired results shall be used. This will permit the most valuable mounts and guns to be saved for that special and emergency work for which only they are adapted.

58. Ordinarily, arrangements for the use of railway artillery may be made very deliberately. If there is plenty of time, the necessity for the use of a cumbersome firing platform may not be a handicap. There is no objection to having the men do the manual labor of putting down a platform since, ordinarily, the battery commander may be hard put to find enough work to keep his men busy and contented. This should not be considered an argument for building such artillery, however, and indeed no battery or group commander with whom the writer has talked would select 340 or 400 millimeter St. Chamond mounts if he had the choice between these and 305 or 370 millimeter Schneider mounts. However, if the Army possesses such mounts and if time is available sufficient to construct the number of emplacements required to cover all the objectives, then there is no objection to the use of mounts having small traverse and elaborate firing platforms.

59. For counter-battery work it is ordinarily necessary to move the guns up and prepare them for action in a minimum of time, this minimum being counted in hours (six or less). It is desirable, likewise, that it be possible to remove these mounts within a half hour or less. In such cases, which are really those emergency cases noted in the previous paragraph, the mounts affording wide traverse or all-round fire and requiring not more than an hour for emplacement will be chosen.

TABULAR CLASSIFICATION OF RAILWAY ARTILLERY.

60. For convenient reference, tables classifying railway artillery in accordance with the preceding are given below. The examples here given are from practice.

Railway artillery classified according to use.

Destruction.	Interdiction.	Counter-battery work.	Distant bombardment.
16-inch Howitzer, American.	14-inch gun, American Navy.	6-inch howitzer, American.	210-millimeter gun of 100 caliber, French.
12-inch mortar, American.	12-inch gun, American.	8-inch gun, American.	8-inch gun, British.
12-inch howitzer, American.	12-inch gun Batig., American.	320-millimeter howitzer, American.	
12-inch gun, American.	340-millimeter gun, French.	240-millimeter gun A. R. F., French.	
10-inch gun, American.	305-millimeter gun, French.	190-millimeter gun A. R. F., French.	
520-millimeter howitzer, French.	274-millimeter gun, French.	170-millimeter gun, German.	
400-millimeter howitzer, French.	240-millimeter gun, French.		
370-millimeter howitzer, French.	14-inch gun, British.		
240-millimeter howitzer, French.	12-inch gun, British.		
200-millimeter howitzer, French.	9.2-inch gun, British.		
12-inch howitzer, British.	380-millimeter gun, Italian.		
240-millimeter howitzer, German.	210-millimeter gun, German.		
420-millimeter mortar, German.	280-millimeter gun, German.		
	380-millimeter gun, German.		

Railway artillery classified according to range.

Short range.		Medium range.				Long range.	
Gun.	Range.	Gun.	Range.	Gun.	Range.	Gun.	Range.
	Km.		*Km.*		*Km.*		*Km.*
12-inch mortar, American	10.0	16-inch howitzer, American	20.0	12-inch gun, American	25.0	14-inch gun, American	38.0
520-millimeter howitzer, French	18.0	12-inch howitzer, American	20.0	10-inch gun, American	24.0	12-inch gun, American	32.0
400-millimeter howitzer, French	15.0	8-inch gun, American	19.0	305-millimeter gun, French	27.0	16-inch gun,[1] American	55.0
370-millimeter howitzer, French	16.4	340-millimeter howitzer, French	20.0	280-millimeter gun, French	31.0	210-millimeter gun, French, 100 caliber.	120.0
320-millimeter howitzer, French	16.3	320-millimeter howitzer, French	21.6	274-millimeter gun, French	27.0	340-millimeter gun, French	37.0
293-millimeter mortar, French	10.7	305-millimeter gun, French	20.0	12-inch gun, British	28.0	14-inch gun, British	32.0
270-millimeter howitzer, French	14.0	285-millimeter gun, French	21.9	9.2-inch gun, British	24.0	8-inch gun, British	110.0
240-millimeter howitzer, French	13.0	274-millimeter gun, French	20.5	280-millimeter gun, German	33.0	380-millimeter gun, Italian	55.0
200-millimeter howitzer, French	11.0	240-millimeter gun, French	22.0	210-millimeter gun, German	26.0	380-millimeter gun, German	55.0
194-millimeter howitzer, French	13.9	194-millimeter gun, French	16.5	170-millimeter gun, German	24.0		
12-inch howitzer, British	13.0	164-millimeter gun, French	18.0				
420-millimeter mortar, German	13.0	240-millimeter howitzer, German	18.0				

[1] American mount projected only.

Railway artillery classified according to traverse.

Nontraversing.	Railway car traversing.		Top-carriage traversing.	
	Limited fire.	All round fire.	Limited fire.	All round fire.
12-inch gun, American.	14-inch gun, American.	380-millimeter gun, German.	16-inch howitzer, American.	12-inch mortar, American.
10-inch gun, American.	340-millimeter gun, French.	280-millimeter gun, German.	12-inch gun, American.	12-inch howitzer, American.
520-millimeter howitzer, French.	285-millimeter gun, French.	240-millimeter howitzer, German.	400-millimeter howitzer, French.	8-inch gun, American.
370-millimeter howitzer, French.	274-millimeter gun, French.	210-millimeter gun, German.	370-millimeter howitzer, French.	7-inch gun, American Navy.
340-millimeter gun, French.	14-inch gun, British.		305-millimeter gun, French.	240-millimeter gun, French.
340-millimeter howitzer, French.	12-inch gun, British.		274-millimeter gun, French.	200-millimeter howitzer, French.
320-millimeter howitzer, French.			12-inch howitzer, British.	194-millimeter gun, French.
305-millimeter gun, French.			9.2-inch gun, British.	164-millimeter gun, French.
274-millimeter gun, French.			170-millimeter gun, German.	155-millimeter howitzer, French.
240-millimeter howitzer, French.				
194-millimeter howitzer, French.				
380-millimeter gun, Italian.				

Railway artillery classified according to anchorage.

No anchorage.	Track platform.		Ground platform.	
	Mount.	Time to build.	Mount.	Time to build.
14-inch gun, American Navy.	12-inch howitzer, American	30 minutes.	16-inch howitzer, American	2-5 days.
16-inch howitzer, American.	12-inch gun, American	2 hours.	14-inch gun, American Navy	1-2 days.
14-inch gun, British.	12-inch mortar, American	30 minutes.	12-inch gun, Batignolles, American	2-3 hours.
12-inch gun, British.	10-inch gun, American	2 hours.	400-millimeter howitzer, French	2-5 days.
9.2-inch gun, British.	8-inch gun, American	30 minutes.	370-millimeter howitzer, Batignolles, French	2-3 hours.
380-millimeter gun, German.	520-millimeter howitzer, French	2 hours.	340-millimeter gun, St. Chamond, French	2-5 days.
280 millimeter gun, German.	370-millimeter howitzer, sliding, French	2 hours.	305-millimeter howitzer, Batignolles, French	2-3 hours.
240-millimeter howitzer, German.	340-millimeter gun, sliding, French	2 hours.	293-millimeter mortar, 1903, French	1 hour.
210-millimeter gun, German.	340-millimeter howitzer, sliding, French	2 hours.	240-millimeter gun, 1903, French	1 hour.
170-millimeter gun, German.	320-millimeter howitzer, sliding, French	2 hours.	305-millimeter gun, St. Chamond, French	5-6 hours.
	305-millimeter gun, sliding, French	2 hours.	380-millimeter gun, German	3 weeks.
	274-millimeter gun, sliding, French	2 hours.	280-millimeter gun, German	1 week.
	270-millimeter gun, French	15 minutes.	240-millimeter gun, German	1 week.
	270-millimeter howitzer, French		210-millimeter gun, German	1 week.
	240-millimeter gun, French, St. Chamond	12 hours.		
	240-millimeter howitzer, French	30 minutes.		
	200-millimeter howitzer, French	10 minutes.		
	194-millimeter gun, French	30 minutes.		
	194-millimeter howitzer, French	30 minutes.		
	12-inch howitzer, British	6 hours.		
	380-millimeter gun, Italian	3 hours.		

The platforms for the sliding and French and American Batignolles mounts can be installed beforehand, and the gun can be run up, fired, and brought back in a very short time. In the case of the sliding type, the platform amounts simply to additional girder rails laid on the ties. Successful experiments have been conducted in which the girder rails were attached to the sleepers of the mount and slid on the ties. In such cases the operation of the sliding mounts becomes almost as rapid as that of mounts firing without preparation.

RELATION OF RAILWAY ARTILLERY TO OTHER TYPES.

61. A consideration of the scope of utility of railway artillery would be incomplete without a presentation of the relation between this and the less powerful types—field and heavy wheeled artillery.

62. If a set of rectangular coordinates be set up, with ordinates representing calibers and abscissæ representing ranges, then any possible objective of artillery fire can be located in the field of these coordinates, its position relative to the nearest available battery location giving the range, and the character and resistance fixing the caliber, plate 58.

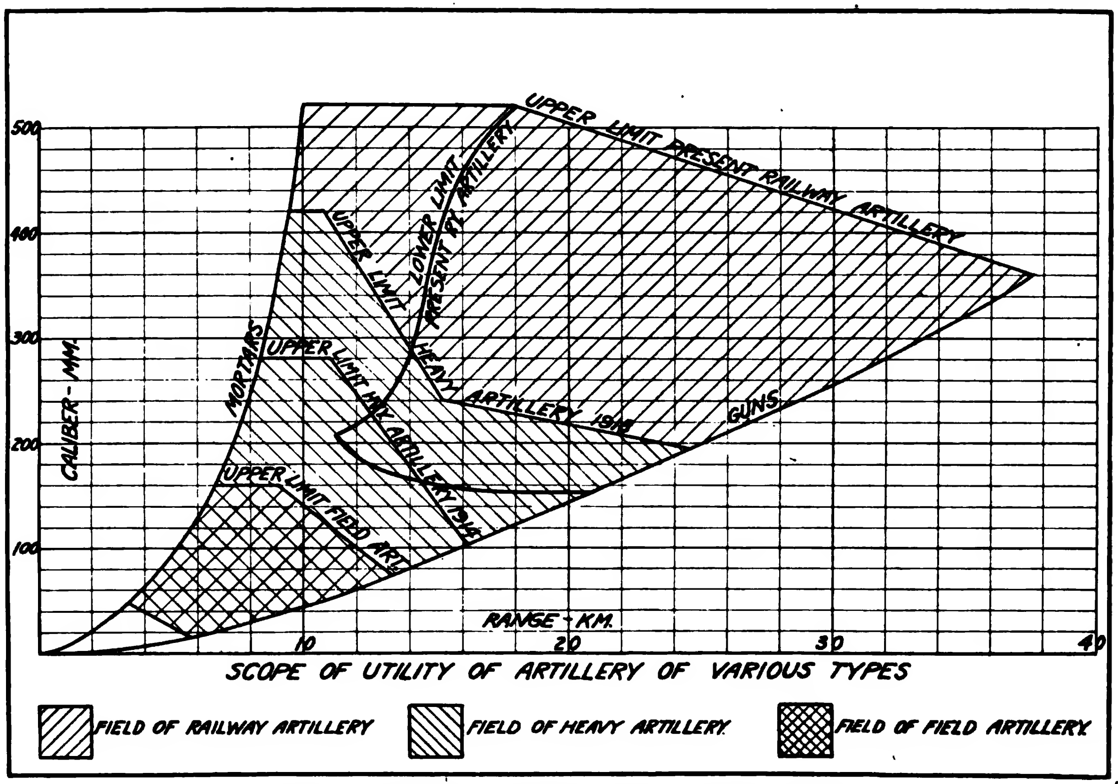
63. A given type of gun may be represented on the above-noted ordinates by a line joining the points representing the objectives it can reach. Mortars, for example, with a characteristic muzzle velocity of approximately 300 meters per second, would be represented by the line to the left on the diagram, joining all points representing a range and caliber requiring 300 meters per second velocity to realize them. In the same way the line at the bottom represents long guns (muzzle velocity about 850 meters per second). Thus the entire field of artillery (except trench artillery and long-range guns) is included between the two exterior lines.

64. A given type such as field or heavy artillery is represented by an area including all the points representing objectives for which the various guns of this type of artillery are suitable. On the diagram, plate 58, a line has been drawn, joining the points representing the heaviest field artillery guns, howitzers, and mortars. Thus the area below this line and between the two limiting lines represents the province of field artillery.

65. A second similar line has been drawn representing the upper limit of heavy artillery at the beginning of the war in 1914. The area between it and the previous line therefore represents the domain of heavy artillery. And, by consequence, the area above and to the right of this line is the domain of railway artillery.

66. For comparison, a line has been drawn through points representing the lightest railway artillery employed by the French. As will be noted, it intersects the heavy artillery line, indicating that railway howitzers were being used where heavy artillery matériel would have served equally well.

PLATE 58



SCOPE OF UTILITY OF ARTILLERY OF VARIOUS TYPES.

67. Developments during the war have, however, considerably changed conditions. All along the line it has become possible to mount heavier artillery on mobile carriages and therefore the line marking the upper limit of heavy artillery has advanced to the position shown by the new curve marked 1918. This, of course, restricts the field of railway artillery and means that still others of the French railway mounts (240 and 270 millimeter howitzers) could be replaced by mobile matériel.

68. The upper limit of the field of railway artillery is not yet marked, as in other arms, by the limitations of the type of mount. Any gun yet constructed can be mounted on a railway mount. The limitation comes in a vertical direction from the resistance of the most difficult objective to be destroyed. Certainly no objective has yet been encountered which the 520-millimeter howitzer or even the 400-millimeter howitzer could not reduce. The opinion gained from a general familiarity with the subject is that, in land warfare, only very exceptional targets will require such calibers and 300 to 350 millimeters is ample for all ordinary purposes.

69. The upper limit of railway artillery in respect to range is also fixed by economic rather than by physical limitations. Guns of extreme range used in distance bombardment for moral effect can perfectly well be mounted on railway carriages, but, as previously pointed out, their utility as compared with bombing planes is a mooted question. Indeed it may be questioned if such planes will not supplant artillery even at shorter ranges.

70. The dispersion of the long-range gun firing on Paris at the range of 110 kilometers was such that 183 of the 303 shots fell inside Paris (area about 90 square kilometers). The shell contained not over 10 kilograms of explosive and the gun had a life of perhaps 50 rounds. Thus the gun could place during its life about 500 kilograms of explosive somewhere within an area of 100 square kilometers.

71. The same results could be secured through the use of light bombing planes operating at a height safe from anti aircraft guns in daylight, and it is probable that dispersion would be considerably less than that noted above (30 bombs were dropped on a single railway shop in Paris). Three light bombing planes could carry the 500 kilograms of explosive just noted and release it on a single raid and even if all the planes were lost, which is not probable, the cost of so delivering the explosive would be considerably less than if it were delivered by the long range gun.

72. The dispersion of the United States 14-inch, 50-caliber gun at the extreme range of about 40 kilometers is about 4 kilometers. It fires a shell carrying about 40 kilograms of explosive and has a life of perhaps 300 rounds. This gives a total of 12,000 kilograms of explo-

sive placed somewhere in an area of 16 square kilometers during the life of the gun.

73. Twenty-five heavy bombing planes could drop this amount of explosive in a single raid, and, even at night, ought to be able to put it inside an area so large as 16 square kilometers.

74. On the other hand, there might be objectives at this range which drop bombs could not destroy because of lack of penetrative power. Further, for interdiction, it frequently is necessary to send over some shells on very short notice and often at times when a plane can not be used at all.

75. The conclusion of the writer is that at extreme ranges, that is, 70 to 120 kilometers, where the firing is for moral effect alone, this service should not ordinarily be considered as a proper one for railway artillery, the use of drop bombs being much more effective.

76. At shorter ranges, approximating 40 kilometers, many cases would seem to exist in fire for destruction and interdiction where drop bombs might be used to better advantage than railway artillery. Some targets would probably be found, however, for which drop bombs are ineffective, therefore railway artillery has a perfectly proper field at these ranges. Further, artillery capable of these ranges is required for accurate fire of destruction at shorter ranges, hence it is available for the longer range work if required.

77. The experiences of the war seem to indicate that the field of usefulness of railway artillery lies between the line on the diagram for heavy artillery, marked 1918, and the line above, joining the heaviest of the present railway guns. In other words, many of the smaller of the present railway guns should not be considered in any new program and there would seem to be little or no advantage in trying to exceed the largest of the present guns. This confines the field of railway artillery to calibers between 200 and 520 millimeters (preferably 250 to 400 millimeters, since there is little need for a caliber greater than 400 millimeters and the 200-millimeter gun can probably be mounted on a caterpillar), and ranges between 10 and 40, or possibly 50 kilometers.

UTILITY IN COAST DEFENSE.

78. Railway artillery has been exploited chiefly in the past as a means of coast defense. The outstanding advantage claimed for it is great mobility, permitting concentration of a large number of guns at any threatened point, and the effective defense of many places which would not justify permanent works, as well as enabling the guns to deliver their fire and retreat before effective counter-battery fire from the sea can be commenced.

79. For this service the work would be primarily the same as that demanded of the present coast-defense guns, i. e., the destruction of

battleships, destroyers, and lighter craft. This service calls for extreme accuracy and rapid fire, in some for long-range direct fire, and in others for medium-range plunging fire. These requirements are quite similar to some of those for land warfare. The essential differences, however, are that while in land warfare, the targets are fixed, in coast defense they are moving, and provisions must be made for following such a moving target; volley firing is often necessary.

80. Specifically the requirements of a mount for coast defense are:

(*a*) Wide traverse (60–180 degrees).

(*b*) Rapid fire.

(*c*) Quick emplacement.

(*d*) Sighting, elevating, and traversing mechanisms which can be operated until the moment the gun is fired, and simultaneously for all guns of a battery.

SECTION 3.

CHARACTERISTICS OF EXISTING TYPES OF RAILWAY ARTILLERY.

---

81. Railway mounts have been constructed and used to our certain knowledge by the French, British, Italian, German, and American Governments. Information on mounts constructed by all of these nations has been collected and tabulated for each type of which anything could be learned. At the request of the technical services of the French and British Governments all descriptions and tabular data on their mounts are omitted from this volume, which is intended for general distribution, and are placed in a separate volume for confidential use only. The tabular data on American and German mounts is given in section 10 of this volume. The descriptions and tabular data of the French, British, and Italian mounts are given in continuations of articles 3 and 10 in Volume II. All of the American and German mounts will be described in detail in this volume, each mount being designated by the number it bears in the table. In Volume II all other mounts will be mentioned, but only those on which special information is available will be dealt with in detail.

82. The various designs described herein are criticized chiefly under the head of "Difficulties involved in service." Most of the mounts are criticized under this head on a basis of the type of firing platform used and the time required for its installation.

83. There are in existence at the present time six types of mounts, according to the characteristic design or nature of their firing platform. These are: (1) Mounts of the type of the American 8-inch, plate 30, or French 200-millimeter, plate 10, using some simple type of outrigger; (2) mounts of the sliding and rolling type, similar to the French 320-millimeter, plate 42, or the American 10-inch, plate 111, and the British 12 and 14-inch rolling mounts, plates 20 and 21, or the American Navy 14-inch mount, plate 23, requiring a curved track of very heavy construction to permit of traversing the mount and to stand the exceedingly heavy service brought upon it in firing; (3) semipermanent emplacement mounts of the type of the American

12-inch Batignolles, plate 54, requiring a firing platform made up of easily handled sections which are carried in a special platform car provided with the necessary equipment for installing them; (4) semipermanent emplacement mounts of the type of the French 340-millimeter gun mount, plate 51, the 400-millimeter howitzer mount, plate 52, and American 16-inch howitzer mount, plate 53, and American 14-inch naval mount, Mark I, plate 23, requiring an elaborate subtrack platform of timber and steel construction which ordinarily can not be installed in less than from two to five days and affords only limited traverse of 10 degrees or less; (5) semipermanent emplacement mounts of the type of the American 14-inch model E mount, plate 249, requiring a heavy base ring of comparatively simple design, but which necessitates the use of a locomotive crane of 150 tons or more capacity; (6) semipermanent emplacement mounts of the type of the German 21, 24, and 28-centimeter mounts, plate 24, requiring a firing platform of structural steel, plate 55, which is cumbersome to transport and requiring crane facilities for installation, or a reenforced concrete emplacement, plate 56, which requires few facilities but considerable time for its installation.

84. So far, the use of the outriggers which are characteristic of class 1, have been limited to guns of smaller caliber and, of course, in criticizing the emplacements for larger guns, they are not being compared with the outrigger scheme of emplacement of these smaller mounts. In comparing the last five classes of mounts where one has a choice of: (*a*) A new curved track of heavy construction, (*b*) a special platform carried in a special car, (*c*) a heavy timber platform requiring days for installation, (*d*) a simple steel base ring requiring unusual facilities in the shape of a locomotive crane for installation, or (*e*) a structural steel platform difficult to transport and requiring days for installation, or a substitute therefor, in the shape of a reenforced concrete platform, apparently any one type has a questionable advantage over another and the various designs described in this section are not criticized on a basis of a preference for any of the types so far mentioned. After careful examination and consideration of all the types of railway mounts in existence, it seems possible to combine in a mount for heavy guns, modifications of emplacement schemes of the above types in such a way as to render the mount almost universally serviceable. On plates 59 and 60 is a suggestion for a design of a carriage for 10-inch, 50-caliber guns. Computation of the necessary data indicates that this type of emplacement can be installed almost as quickly and as easily as the simple outrigger emplacement. It gives all round traverse if desired and will stand the strains brought upon it by a 50-caliber, 10-inch gun.

PLATE 59

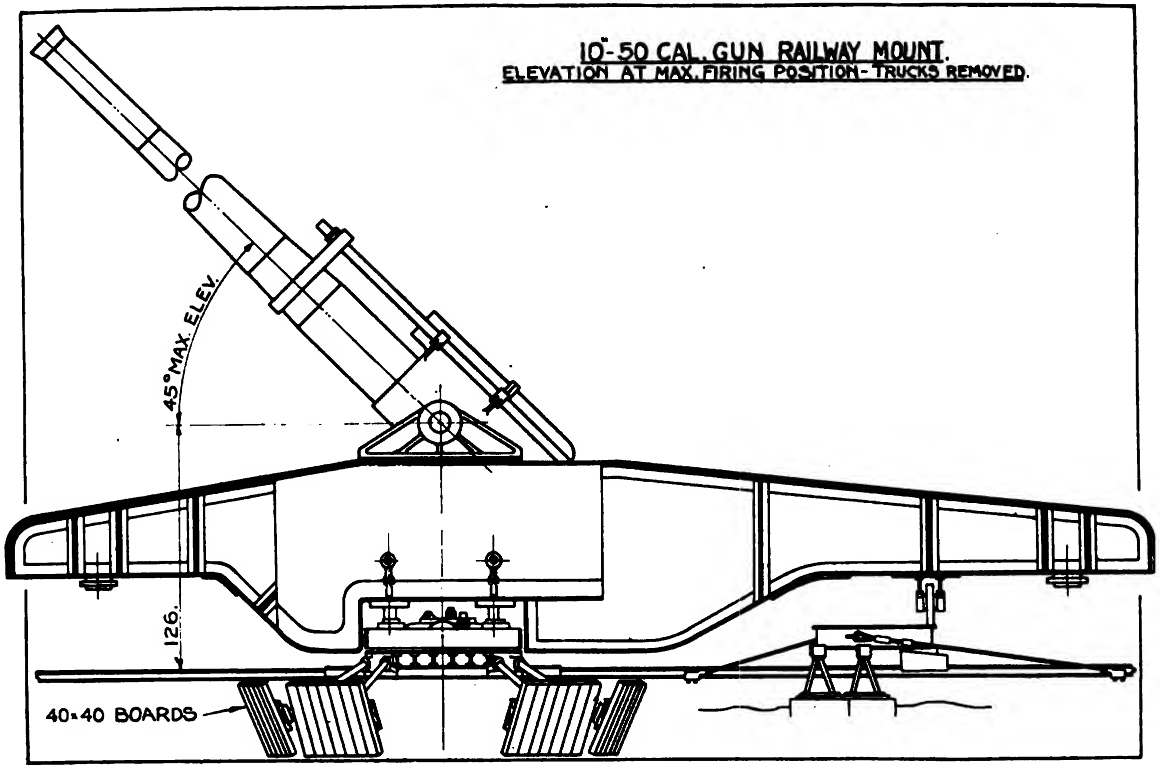
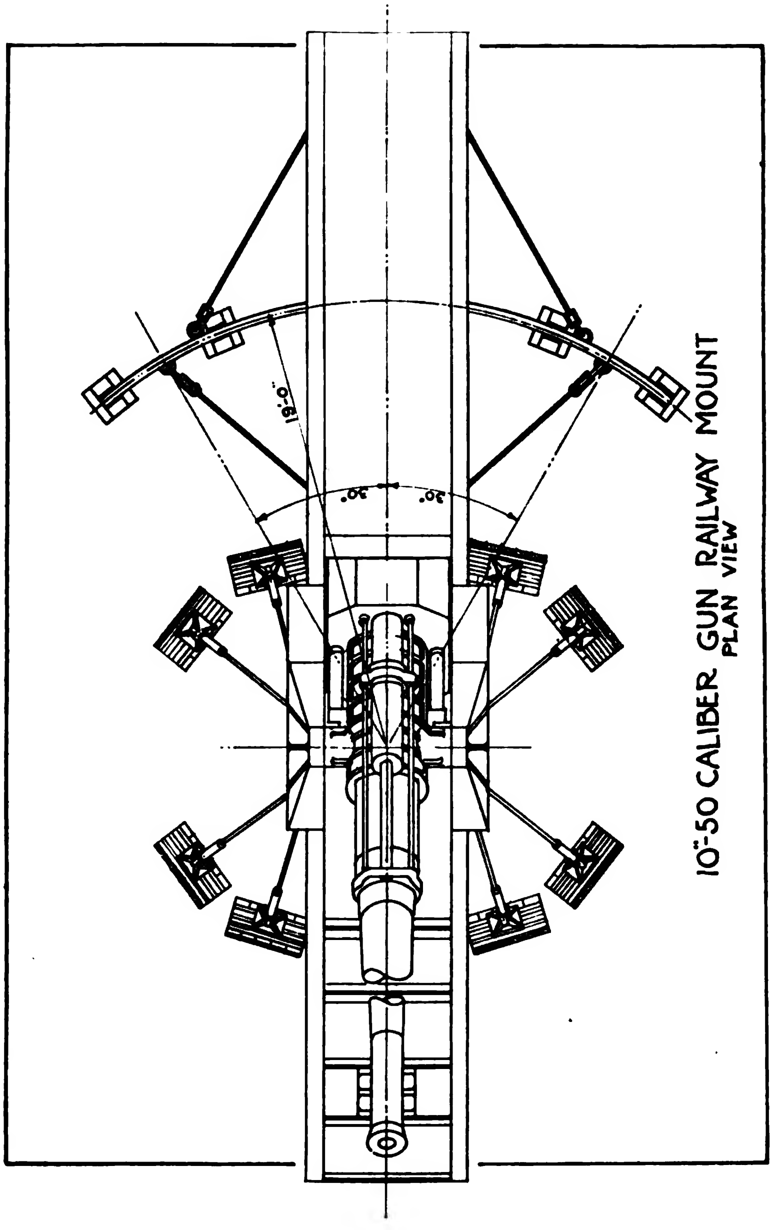

10" - 50 CAL. GUN RAILWAY MOUNT.
ELEVATION AT MAX. FIRING POSITION - TRUCKS REMOVED.
45° MAX. ELEV.
126.
40×40 BOARDS

PLATE 60



10"-50 CALIBER GUN RAILWAY MOUNT
PLAN VIEW

85. Going a step further, it seems entirely feasible to design a mount which will embody the features of the sliding type mount in the shape of steel shoes similar to those used on the 14-inch model E mount and the features of the mounts of classes 1 and 6 in the shape of a center pivot and traversing rollers attached to the car body to secure the necessary traverse, and outriggers on the rear of the car body to take a large part of the horizontal component of the force of recoil. In addition, it seems possible to incorporate other features of the 14-inch model E mount, in the shape of a simple base ring which will be set on the concrete and on which the mount can be operated for seacoast service. These simple base rings would be inexpensive and could be installed in great numbers along our coast at comparatively little cost. This type of mount would then service perfectly as a coast defense mount, and for land warfare could be used as a combined sliding and rolling mount with any desired traverse, or as a simply and quickly emplaced mount requiring very few extra facilities and having any desired traverse.

86. The writer has these two types in mind in criticizing the various mounts throughout this section, from the standpoint of time, and difficulties involved, and facilities necessary in placing, removing, and maintaining their platforms.

1.—4.7 HOWITZER ON RAILWAY MOUNT. (13)

87. This mount, which is model of 1917, was designed as an alternate mounting for the pivot yoke and other rotating parts of the 4.7-howitzer pedestal mount, model 1915. The railway carriage resembles very closely the design made up by Col. Peigne for the 155-millimeter French howitzer, 1890. This can be seen by comparison of plates 62 and 65 with plate 4. Four of these mounts were completed for service at Panama, and have functioned satisfactorily.

88. Guns.—The gun that is used with this mount is a 4.7 howitzer, model 1913. It is a wire-wound gun of 22.5 caliber length, plate 66, and is provided with the standard American type interrupted thread breechblock, which is fitted with a mechanical firing mechanism, plate 67. The tube is rifled with 42 grooves, the twist of which is to the right and at a pitch increasing from 1 turn in 40 calibers to 1 turn in 20 calibers. As mentioned before, this same model of gun is used on the pedestal mounting, model 1915.

89. Recoil Mechanism.—The recoil mechanism is of the hydro-spring type and as with the light field pieces, the entire recoil mechanism is combined in one cylinder, plate 68. It will be noted on this plate that the hydraulic cylinder recoils with the gun while the piston remains stationary. The counterrecoil buffer is not a part

of the piston rod as in the usual railway design, but is attached to the cylinder. The hydraulic cylinder head serves as a piston head for the recuperator spring column. The length of recoil is 12 inches.

90. Elevating Mechanism.—It is possible to elevate the gun from minus 10 degrees, the loading angle, to plus 40 degrees, by means of the screw hinged to the bottom of the cradle at its forward end, plate 69. This screw is driven by the bronze nut in the oscillating central bearing. This bearing is supported on the cross shafts as trunnions. Elevating handwheels are provided on both sides of the carriage.

91. Traversing Mechanism.—The gun can be traversed through 360 degrees. The traversing mechanism comprises the handwheel shaft and bevel gears shown on plate 70, with the worm shaft, worm and bronze wormwheel shown on plate 69. The lower portion of this bronze wormwheel serves as a drum for the two halves of the friction band which are hinged on the stud bolt, passing through the boss in the rear of the pedestal. The two halves of this friction band are joined at the front by a bolt.

92. Top Carriage.—The top carriage comprises the cradle carrying the hydrospring recoil mechanism and the pivot yoke with the elevating and traversing mechanisms, plate 69. On this plate the gun is shown on the pedestal for which it was originally designed. On the railway mount the pedestal is part of the car body, but its design, as well as the dimensions of its machined surface are identical. Any gun of this design with its pivot yoke can be transferred from the separate pedestal to the railway mount. The weight of the gun, cradle, and pivot yoke is carried on ball thrust bearings at the bottom of the pedestal. The separate pedestal is provided with an azimuth circle which is not provided on the pedestal of the railway mount. Front and rear views of the top carriage are shown on plate 71, and a right-hand side view on plate 72.

93. Railway Car Body.—The railway car body proper, plate 73, comprises a central steel casting, of which the pedestal is an integral part, and the two structural steel ends riveted to this casting. On each side of the car body two side arm castings are riveted, both to the cast steel center section and the structural steel ends. On each end of the car body are hinged three pieces of 0.5-inch armor, the side pieces having two copper lined loop holes for machine guns, and the end pieces one copper lined loop hole each. These plates of armor can be let down to a horizontal position to serve as working platforms. Two other plates which serve likewise as working platforms are hinged to the central cast steel section of the car body.

94. Anchorage.—The mount is let down and clamped to the track for firing. Additional provision is made for stabilizing the mount when the gun is fired at any considerable angle to the direction

of the track. Side arms are attached to the car body on each side by means of the side arm castings shown on plate 73. A jack screw passes through the end of each of these side arms and cast steel foot plates of simple design are provided on which the screws bear. These foot plates are placed on well tamped earth, rock ballast or timber. When firing at a wide angle to the track, it is necessary to put out the side arms on both sides of the car, since the return of the gun to battery has a tendency to tip it in the direction of fire.

95. In the four corners of the central section of the car body there are openings into which rail hook casings are fitted and bolted by four bolts, plate 74. These casings, which may be taken out and turned through 180 degrees, and replaced, are so designed that one arrangement spaces the hooks for the 60-inch gauge track, and the other for the 56.6-inch gauge. Inside of this casing there is a sleeve, two parts of which project above the top of the casing and are fitted with handles as shown on figure 3, plate 74. By means of these handles the sleeves can be raised or lowered. A 0.875-inch pin across the bottom of this sleeve, figure 3, passes between the rail hooks and spreads them when the sleeve is raised, thereby freeing the hooks from the rails. The two rail hooks are hinged to the bottom of the clamping screw, which is operated by the two-handled nut shown at the top of the casing, figure 2. The sleeve and rail hooks are carried normally at their highest position. When it is desired to clamp the car body to the rails, the hooks are lowered as far as they will go As they are lowered, the pin in the sleeve spreads them and the lugs on the hooks strike the top of the rail when they are in the proper position. The sleeve is then lowered by its handles, and as it descends the opening pin permits the hooks to swing together and close over the rail. The bottom of the sleeve encircles the rail hooks and when in its lowest position binds them to the rails. On the under side of the center section of the car body there are six pads which rest on the rails when the mount is lowered to the firing position. These are of sufficient width to be adapted to the 60-inch or the 56.5-inch gauge. Each is provided with a pair of rail stops, one on each side of the rail, which serve to prevent the mount from sliding across the rails and take the strain off the truck pintles. One stop is longer than the other and they are interchangeable. For the 56.5-inch tracks the long stops are placed outside the rails and for the 60-inch tracks they are placed on the inside.

96. In the center of each of the structural steel ends of the car body there is installed a screw lifting jack used in lowering the mount on to the track for firing and in raising it to the traveling position. These jacks are shown in figures 1 and 3, plate 74. This lifting jack comprises a cast-steel pintle guide rivetted into the car body, a bronze pintle, a jack screw, bevel gears, spur gears, and two handles,

figure 1, plate 74. A roller thrust bearing is provided between the top of the jack screw and the top of the pintle guide. The bottom of the pintle rests on the center plate of the truck. Into the two sides of the pintle are machined racks, which mesh with one of the four pinions. The fourth pinion meshes with a rack in the side of the moveable side bearing. As the pintle moves up or down, the side bearing moves in the same direction at the same rate. The first two railway mounts of this type manufactured were also equipped with an alternate method of operating the jack screw. The upper end of the jack screw was slotted and a capstan head provided to fit into it. Four maneuvering levers were provided for the operation of this capstan. The crank handles used to operate the lifting jack may be replaced by ratchet levers. The additional leverage obtained through the use of these ratchets reduces considerably the effort required for raising and lowering the car. When ratchet wrenches are used with a lever arm of 32 inches, the force necessary on each ratchet lever, one being used at a time on each end of the car, is 65 pounds to raise, and 50 pounds to lower. The time necessary to raise the car, using ratchet wrenches, eight men working in reliefs of four, is 5.5 minutes, and to lower ready to fire, approximately 5 minutes. When capstans are used the pull necessary at the end of one lever to turn the capstan at one end of the car is 150 pounds to raise and 100 pounds to lower. When four maneuvering levers are used with one man at each lever, eight men in all, the car can be lowered in 1 minute and raised in 1.25 minutes. When crank handles are used the force necessary on each of the four handles is 85 pounds to raise the car, and 50 pounds to lower. The time necessary to raise the car with crank handles, four men at each end of the car, is 1.5 minutes, and to lower, 2 minutes.

97. Armor.—Each end of the car is fitted with three shields of 0.5-inch armor plate hinged to the floor so that they can be swung down to a horizontal position, plate 73. When raised, the side shields are locked to the end shield by angle iron clips and a locking pin. The two pieces of angle iron are rivetted to the side shield and straddle the end shield when vertical. A single pin locks a side shield to the end. The outsides of the shields are fitted with shield props which slide through guides on the car body. Collars on these props limit the movement of the shields. The upper end of the props extend through the shields and provide an attachment for handle rods on the inside. Three of these handle rods can be seen at the right end of the car, plate 73, the shield on the near side in this case being cut away to show the opposite side. Men standing on the car and clasping hands can let down the side shields by means of these handles without undue difficulty.

98. Trucks.—The trucks are commercial four-wheel trucks of 50,000 pounds capacity. The brake mechanism has been modified slightly to take a special brake bracket in order that the brake handwheel might be located in the free space beside the lifting jack toward the center of the car.

99. Ammunition Supply System.—No special provisions have been made for supplying ammunition for this caliber of gun. All the ammunition components are of such weight as to enable them to be handled entirely by hand.

Plate 61

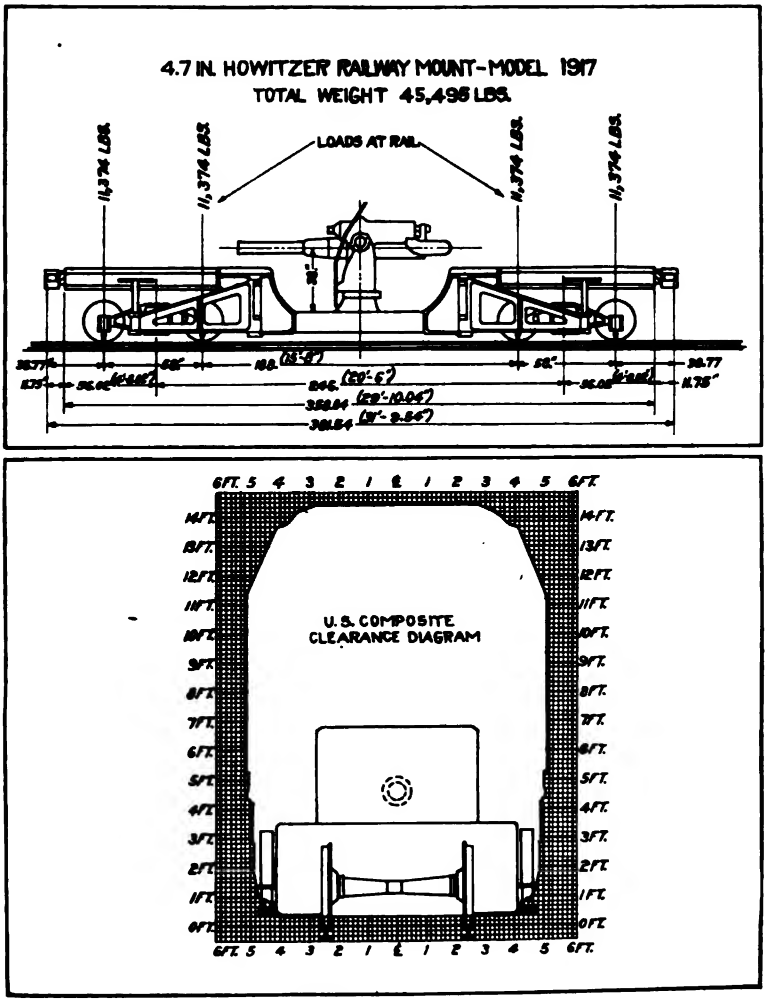
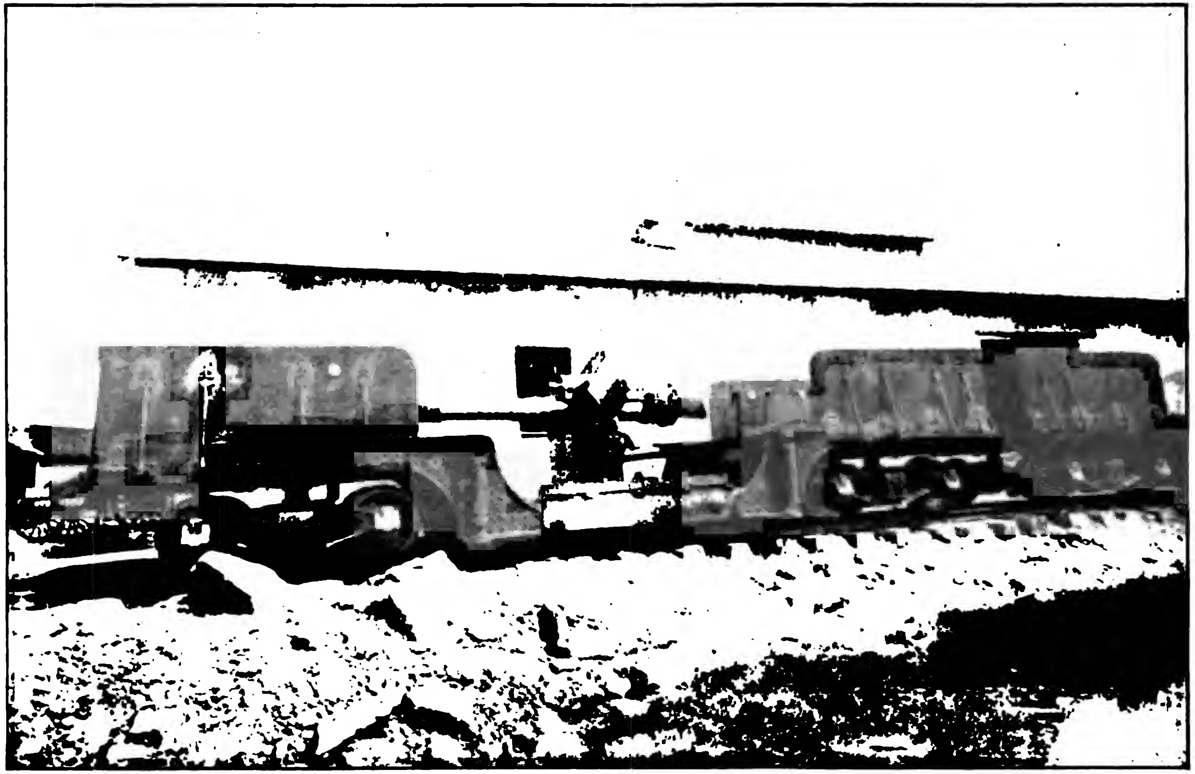


PLATE 62



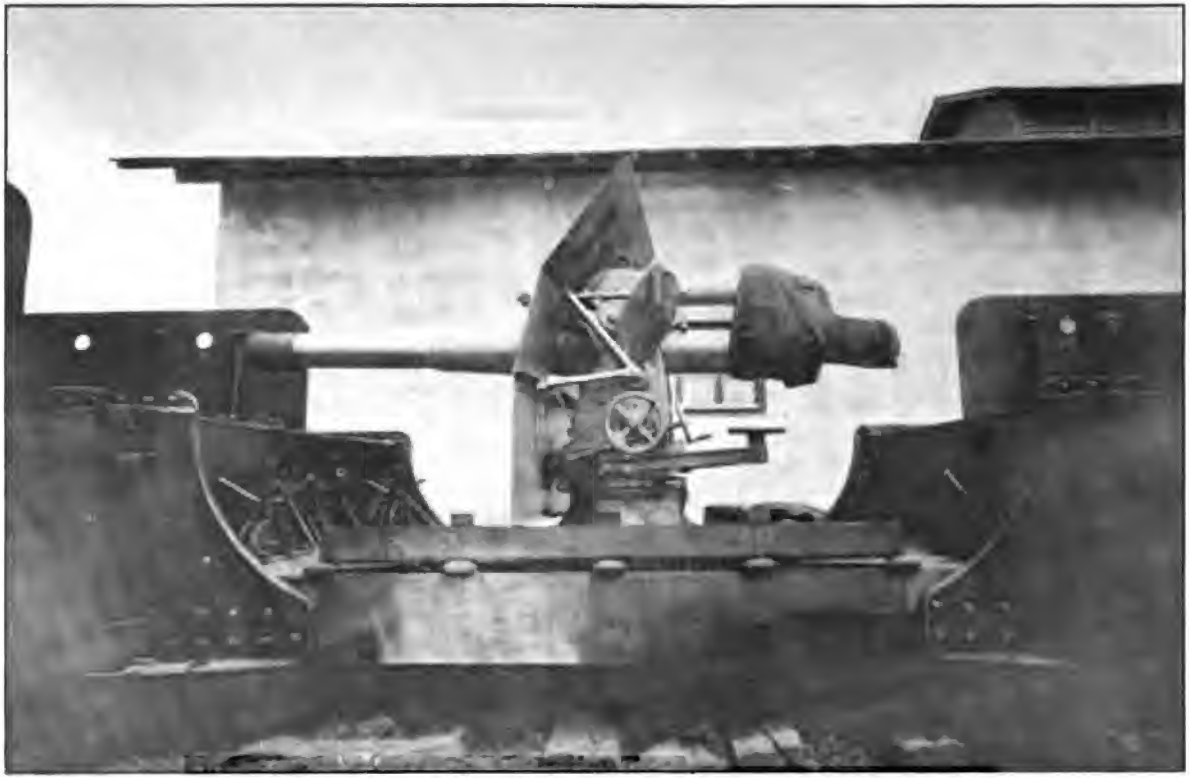
4.7-INCH AMERICAN HOWITZER ON RAILWAY MOUNT (SIDE VIEW).

PLATE 68

4.7-INCH AMERICAN HOWITZER ON RAILWAY MOUNT (FRONT END VIEW).

PLATE 64

4.7-INCH AMERICAN HOWITZER ON RAILWAY MOUNT (REAR END VIEW).



4.7-INCH AMERICAN HOWITZER ON RAILWAY MOUNT (SIDE VIEW ASSEMBLY).

Plate 66

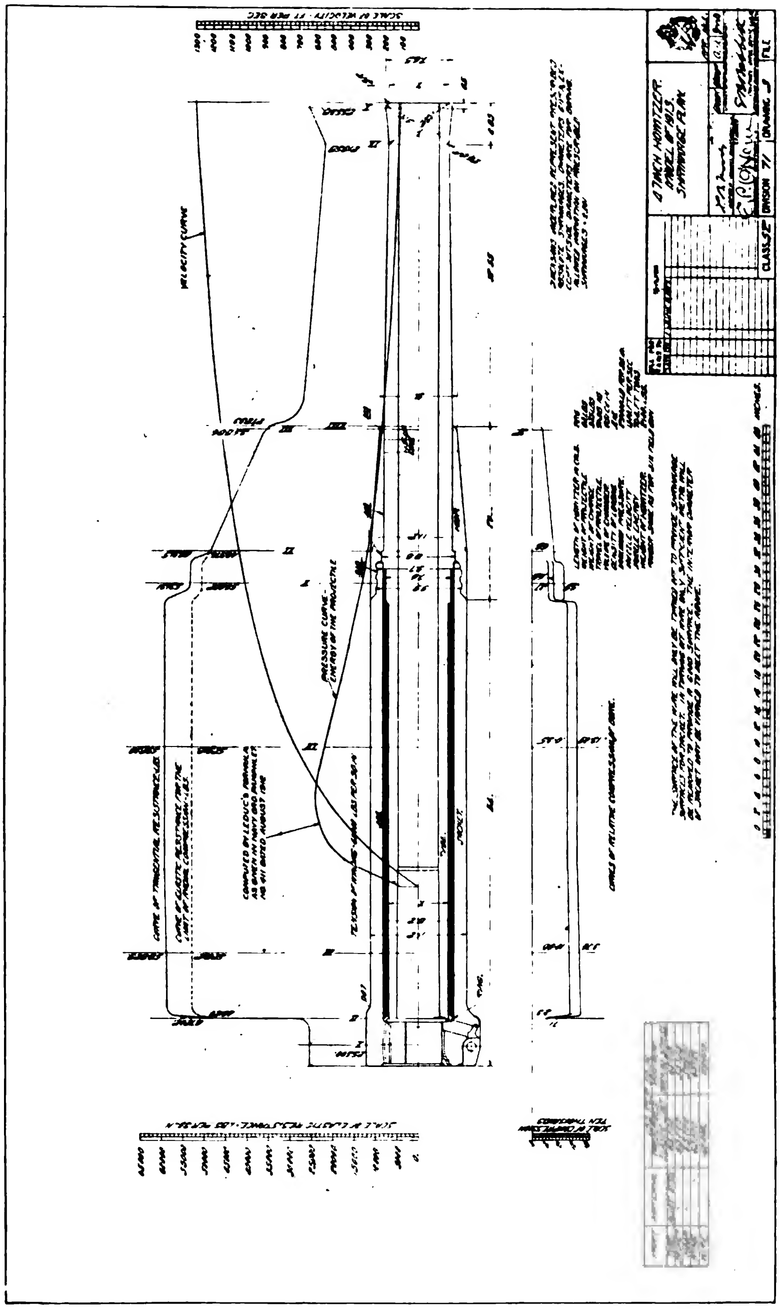


PLATE 67

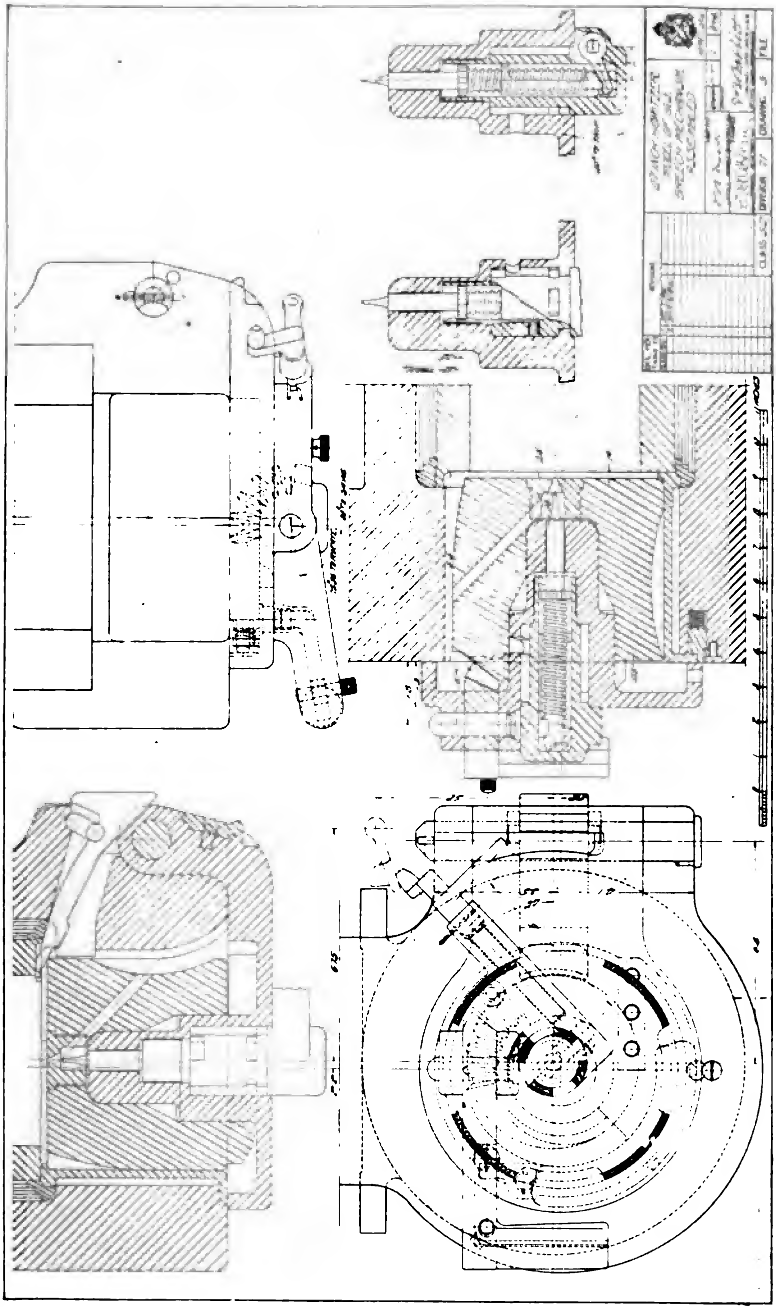


PLATE 68

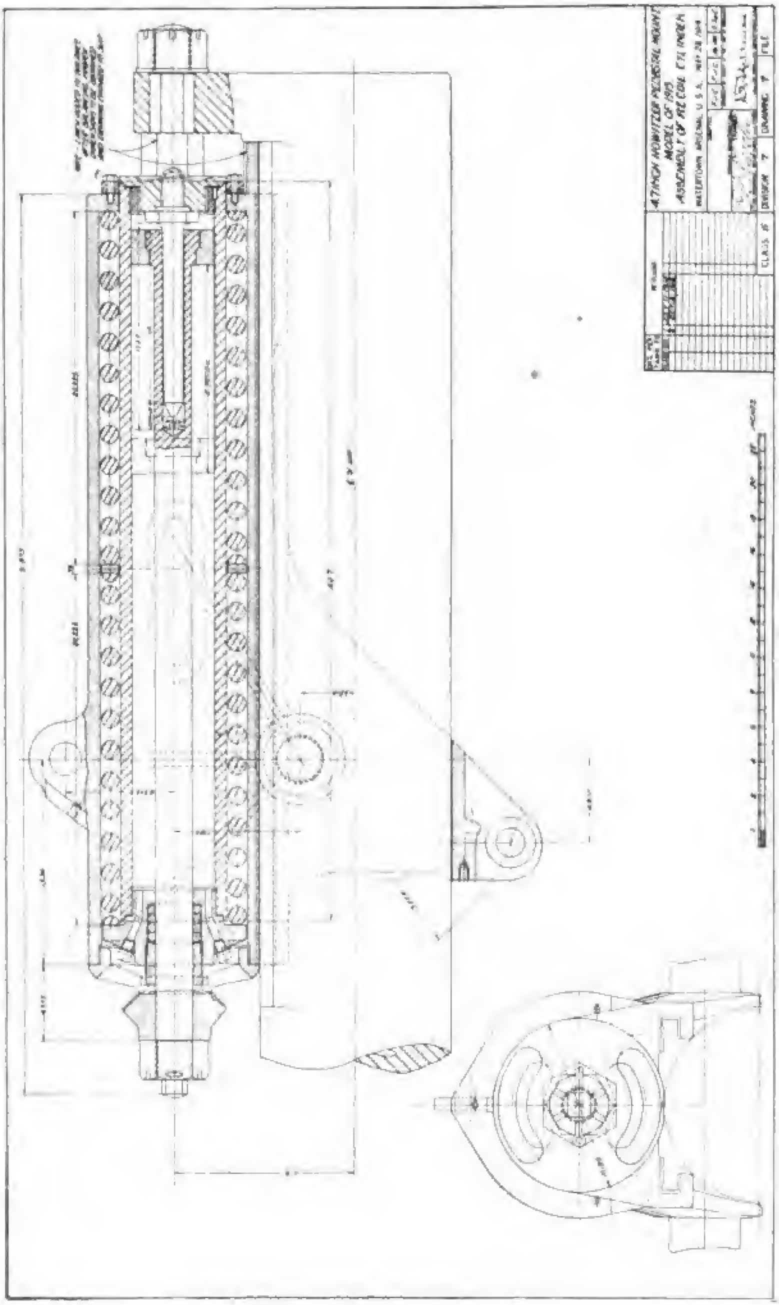
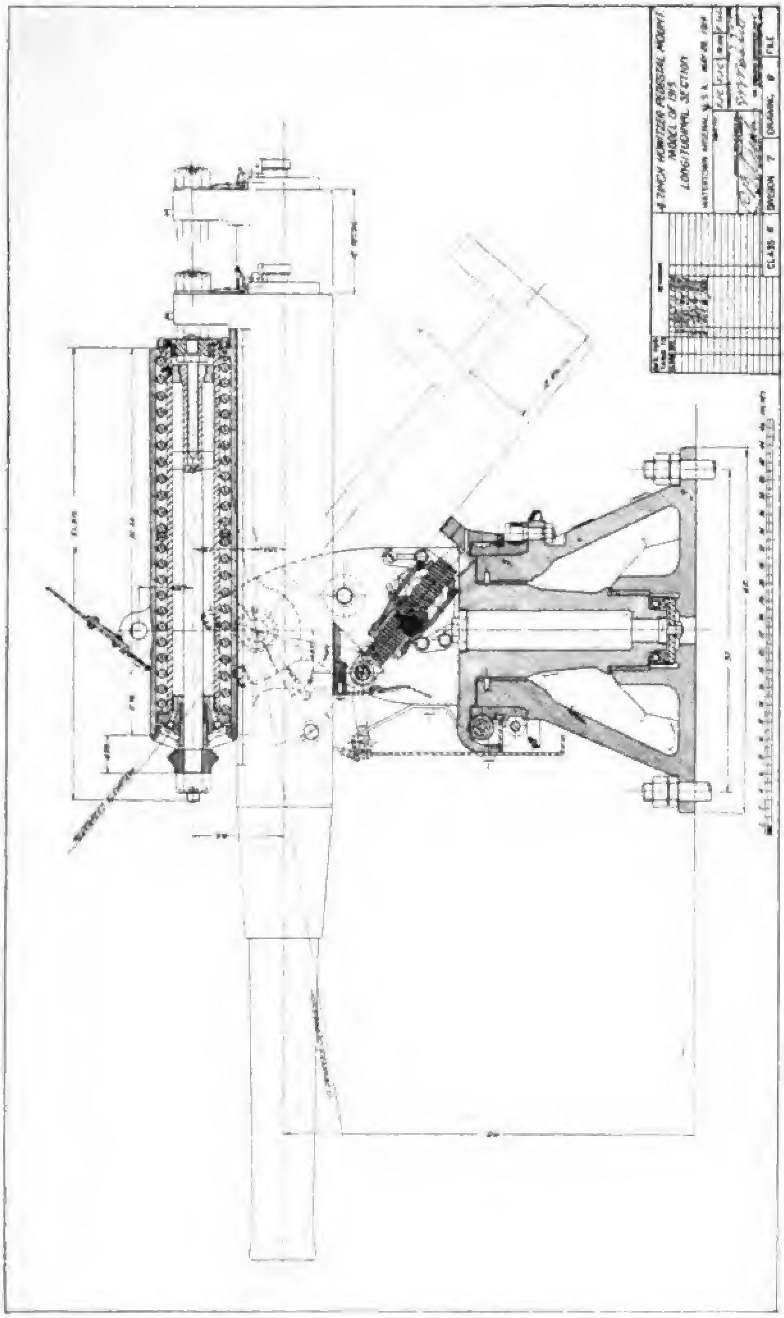

4.7 INCH HOWITZER PEDESTAL MOUNT
MODEL OF 1915
ASSEMBLY OF RECOIL CYLINDER
WATERTOWN ARSENAL U.S.A.
CLASS
DIVISION
DRAWING
FILE

PLATE 69



181768—21——8

PLATE 70

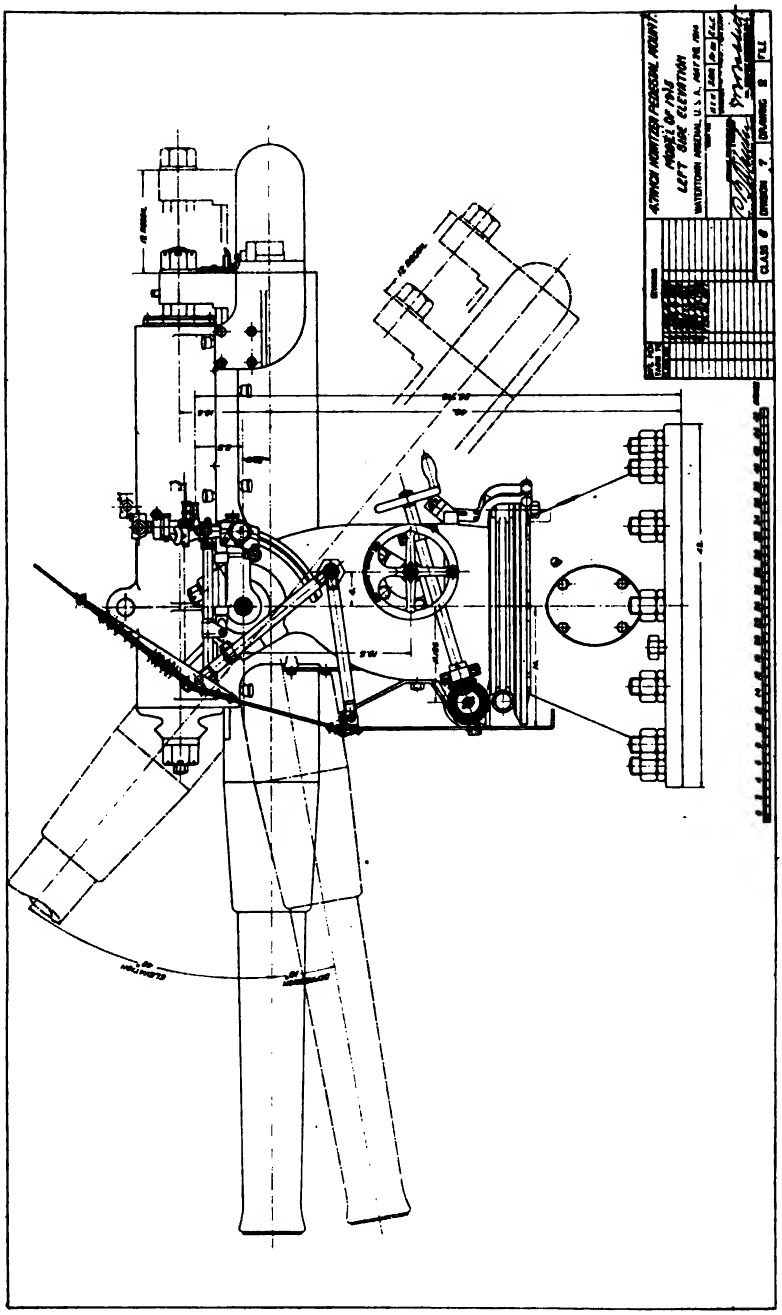

4.7-INCH HOWITZER PEDESTAL MOUNT.
MODEL OF 1915
LEFT SIDE ELEVATION
WATERTOWN ARSENAL, U. S. A.
CLASS 6
DIVISION 7
DRAWING 8
FILE

PLATE 71

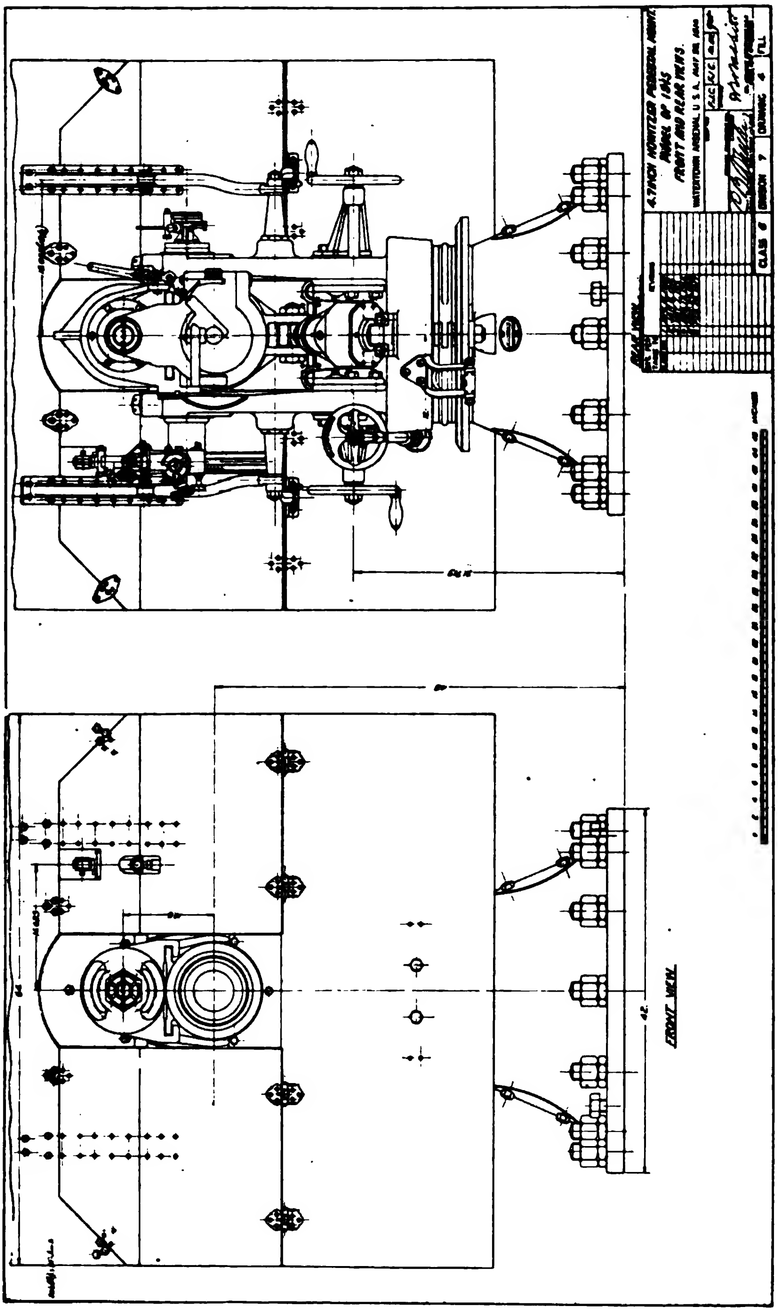


PLATE 72

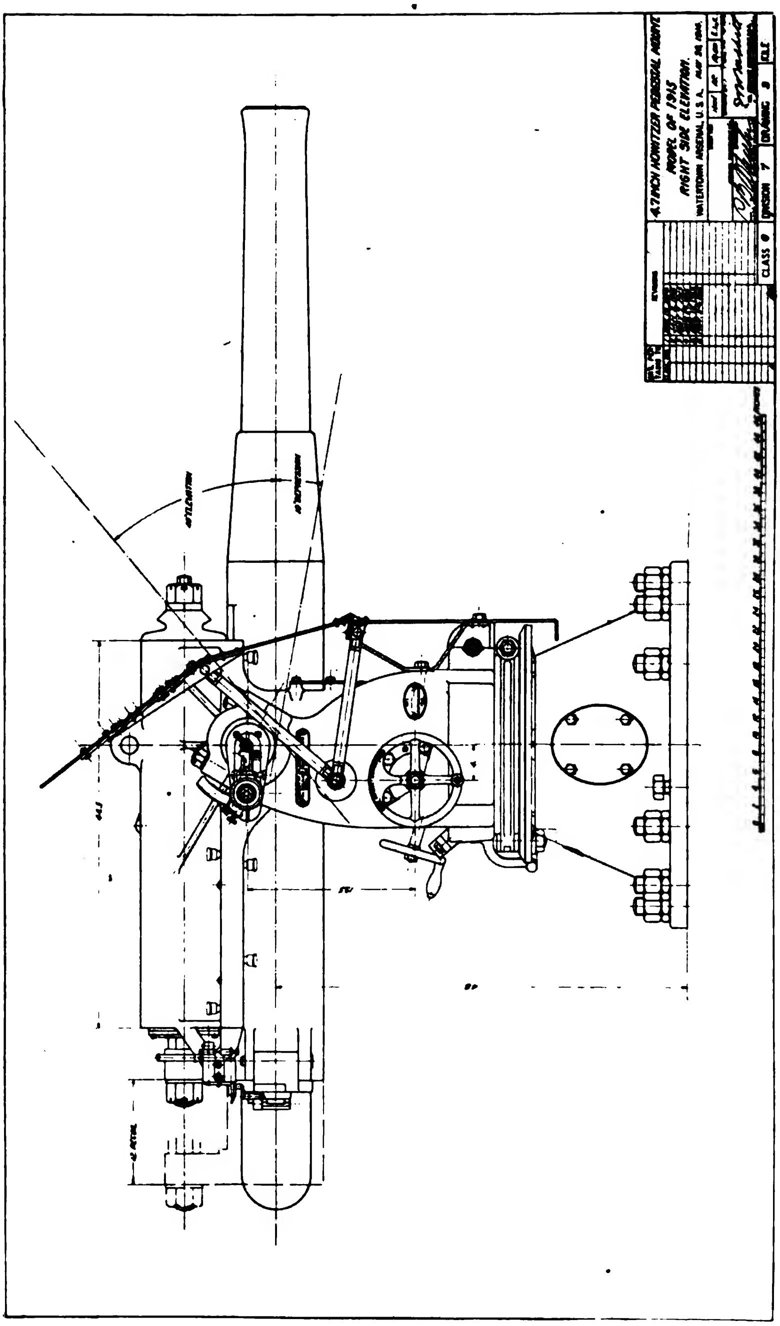

4.7 INCH HOWITZER PEDESTAL MOUNT
MODEL OF 1915
RIGHT SIDE ELEVATION.
WATERTOWN ARSENAL U.S.A.
CLASS
DIVISION 7
DRAWING
FILE

PLATE 73

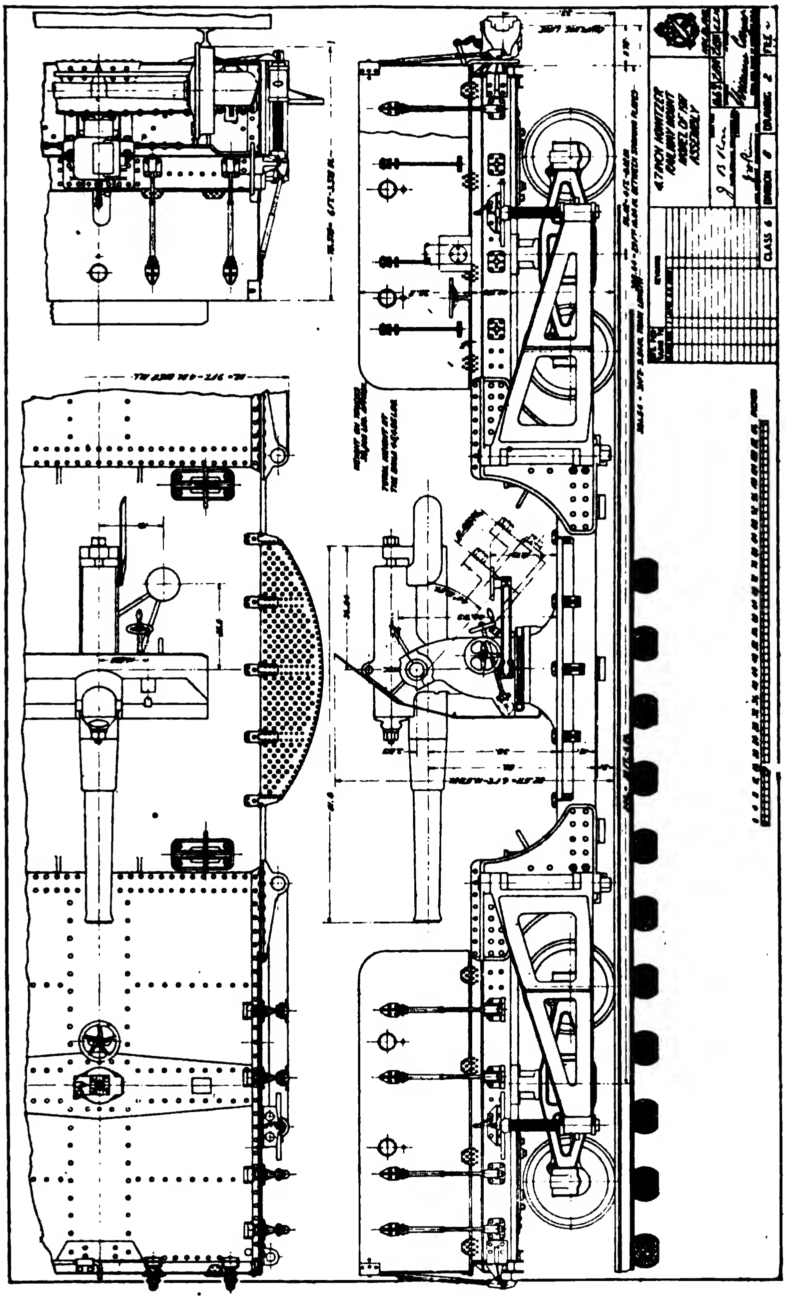

4.7 INCH HOWITZER
RAILWAY MOUNT
MODEL OF 1917
ASSEMBLY
CLASS 6
DIVISION 8
DRAWING 2

PLATE 74

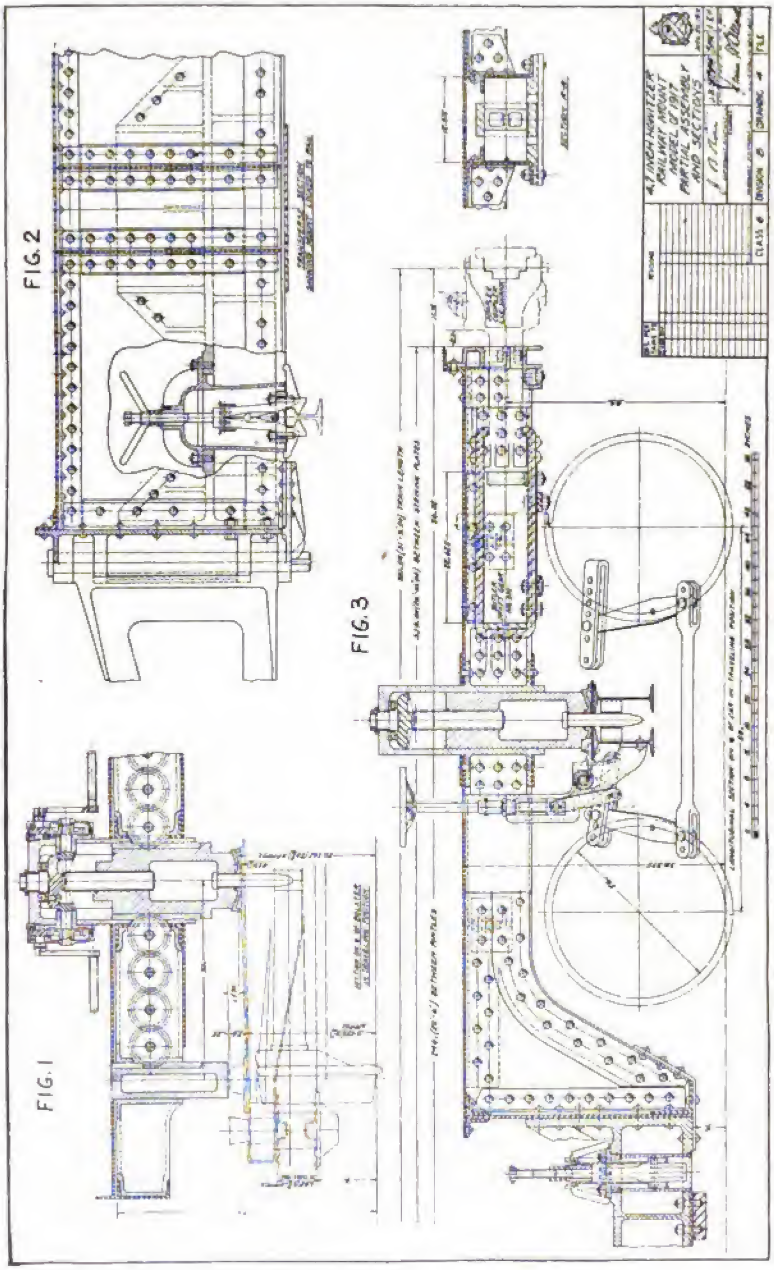


FIG. 1
FIG. 2
FIG. 3
4.7 INCH HOWITZER
RAILWAY MOUNT
MODEL OF 1917
PARTIAL ASSEMBLY
AND SECTIONS

2.—7-INCH GUN ON RAILWAY MOUNT. (14)

100. This combination of Navy gun on Army design of drop-platform car was made up toward the end of the active period of the war, in 1918. The railway cars, model 1918, were designed for 6 and 8 inch seacoast guns, as will be explained later, being modeled to a certain extent after the design already completed for 4.7-inch howitzers. Twelve of these cars were available, and since they were equipped with hydraulic jacks over each of the trucks, it was decided in 1918 to mount Navy 7-inch guns on them for service against submarines along our coast. A few especially designed pieces of equipment were added as will be described later.

101. GUNS.—The guns that are used on these mounts are 7-inch, Mark II Navy guns, of 45 caliber length. They are provided with an interrupted thread breechblock which is fitted with a mechanical firing mechanism.

102. RECOIL MECHANISM.—The recoil mechanism is of the hydro-spring type and comprises one hydraulic recoil cylinder attached to the cradle, in the center of the bottom, and two spring recuperator cylinders likewise attached to the bottom of the cradle, and on either side of the hydraulic cylinder. The hydraulic recoil cylinder is shown in detail on plate 78 and the general arrangement of cylinders on the bottom of the cradle, on plate 79. The length of recoil is 21 inches. The spring columns, which are double, are divided by spacing plates into five sections, plate 80.

103. ELEVATING MECHANISM.—The elevating mechanism comprises a rack attached to the left side of the cradle, plate 80, which is connected with the handwheel through a pinion, shaft, slip friction device, wormwheel, worm, bevel and miter gears, plates 81 and 82, sections ZZ and YY. The gun can be elevated from minus 5 degrees to plus 15 degrees. The cradle trunnions are provided with a very simple type of friction-reducing mechanism, as shown on plate 81.

104. TRAVERSING MECHANISM.—The gun can be traversed through 360 degrees. The traverse wormwheel is attached to the pedestal, as shown on plate 77, and is connected with the handwheel on the right side of the carriage through a worm, two sets of miter gears, sections XX and VV, plate 82. The pivot yoke is supported on the pedestal by means of conical rollers, plate 83.

105. GUN CARRIAGE.—The top or gun carriage comprises the cradle, with recoil, elevating and traversing mechanisms, pivot yoke and pedestal, plates 81, 79, 84, and 85. It will be observed on plates 76 and 77 that the original deck mounting of this gun is so low that it was necessary to provide an additional cast steel base to elevate the gun sufficiently to permit it to be fired at its maximum elevation of 15 degrees when firing in the direction of the track. This cast steel base has been bolted to the floor of the car and additional

cast steel brackets have been added to the side of the car to accomodate the additional width of the base over the width of the car.

106. Car Body.—At the beginning of this discussion it was mentioned that this car body was originally designed for 6 and 8 inch seacoast guns. It was found impossible to use them because the bottom outside angles in the well of the car extended beyond the clearances permissible on European railways. Attention should be called to two other modifications that were made in the car body, model 1918, Mark I. It will be observed on plate 769, that the outrigger struts are attached to the car body by means of cast steel hinges, and from the bottom of the hinge to the end of the strut there is a torsion rod for the purpose of counteracting certain tendencies of the car to jump when gun is fired at low elevations. On the modified design, plate 88, one set of four struts is attached to the car by means of ball joints. Four more struts are attached in such a way as to swing only in one vertical plane, as shown on plate 98. The car under discussion is likewise provided with hydraulic jacks over the truck center plates and with adjustable side bearings, plate 86. The pumps for these jacks are installed on the sides of the car, as shown on plate 76, and connect with the inside of the hydraulic cylinder through the small hole in the piston. Two racks meshing with pinions which in turn mesh with racks cut in the side of the adjustable side bearings are machined into the side of the cylinder which also serves as a body center plate. As the car is raised or lowered the side bearing clearance between truck and body is held constant, due to the action of this compensating device. In the modified design, these jacks and adjustable side bearings were omitted and four jackscrews were placed at the four corners of the lowest part of the flat car.

107. Anchorage.—The mount is emplaced for firing by first injecting sufficient pressure in the hydraulic cylinders to remove the safety locking pins. It is then dropped to the rails by releasing the pressure in the cylinders. No special emplacement is required. The outriggers and floats are placed, as shown on plates 76 and 77, for firing in any direction. It is necessary to put out four outriggers since the car whips to such an extent as to loosen the outriggers if only two are used.

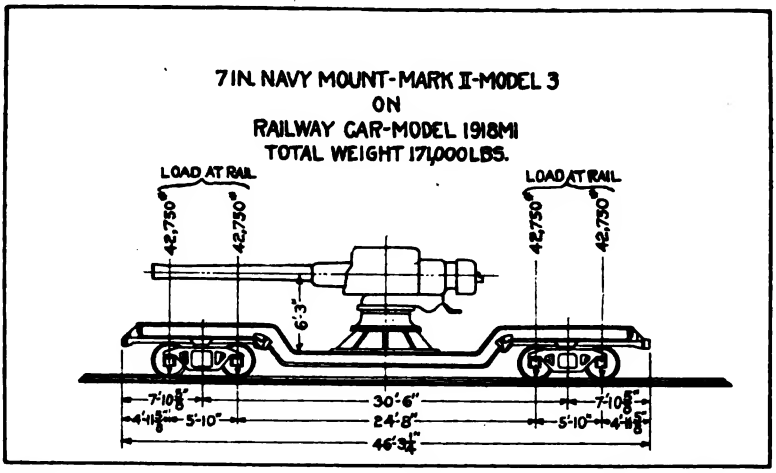
108. Trucks.—The trucks used are of standard M. C. B. design with cast steel side frames. They are provided with both hand and air brakes.

109. Ammunition Supply System.—Projectiles are supplied directly from the ammunition car on to the ammunition table, shown on the end of the car body in plate 77. On the side of this ammunition table are two working platforms which are let down to a horizontal position. The projectiles are transferred from the table into the gun

over the removable tray which can be seen on the top of the table on plate 77. This ammunition table is light in design and is merely bolted to the car; it can be transferred to the other end of the car without difficulty whenever desired. The ammunition cars used with this mount are standard 8-inch ammunition cars.

110. MAINTENANCE, MERITS, DEMERITS.—It is believed that there is no point in discussing the 7-inch mount under these headings, since they are purely emergency mounts and it is believed that they do not represent a type that would receive consideration for future construction.

PLATE 75



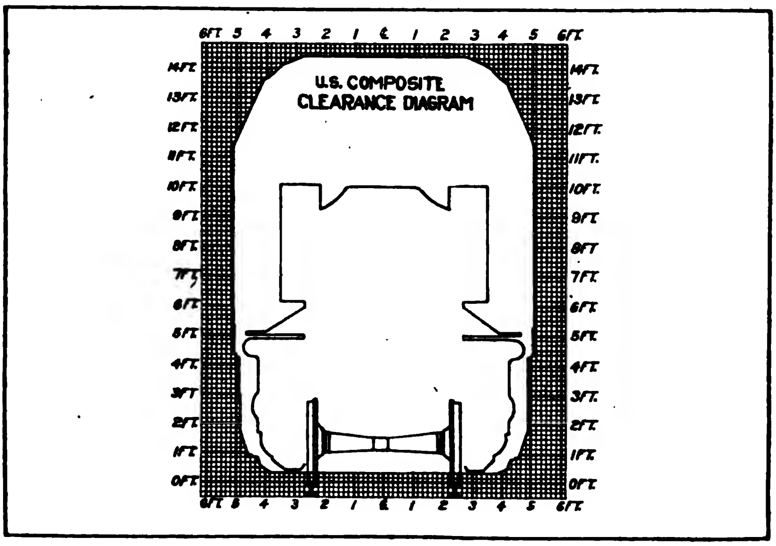


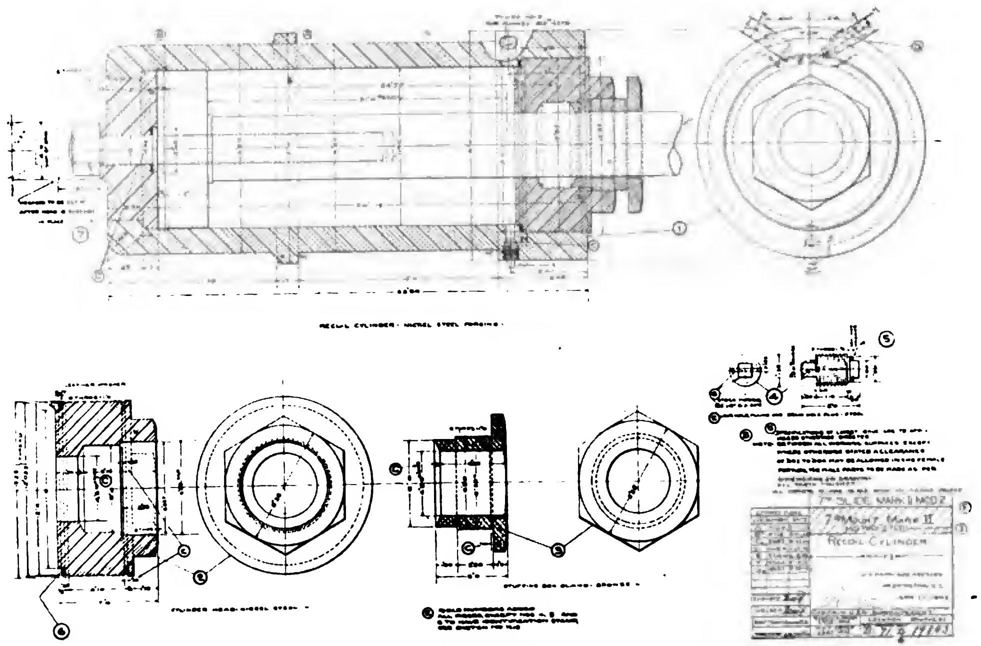
PLATE 76

7-INCH AMERICAN NAVAL GUN AND DECK MOUNTING ON 8-INCH RAILWAY CAR BODY, MODEL OF 1918, MARK I.

PLATE 77

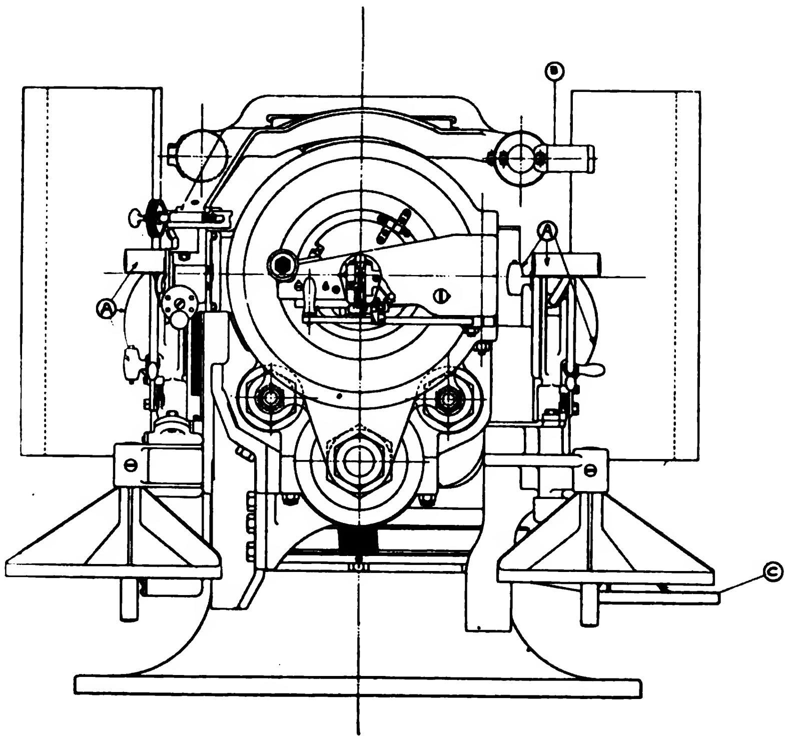
7-INCH NAVAL GUN AND DECK MOUNTING ON 8-INCH RAILWAY CAR BODY, MODEL OF 1918, MARK I.

PLATE 78



RECOIL CYLINDER OF THE 7-INCH AMERICAN NAVAL GUN.

PLATE 79



FOR OTHER VIEWS SEE DRAWINGS NOS. 35868 35869 & 35871

7" MOUNT MARK II. MOD. 3.

GENERAL ARRANGEMENT
REAR VIEW

SCALE 1/8

U. S. NAVAL GUN FACTORY,
WASHINGTON, D. C.

Aug 26 1910

CAPTAIN U. S. N., SUPERINTENDENT

B 71 6 35870

PLATE 80

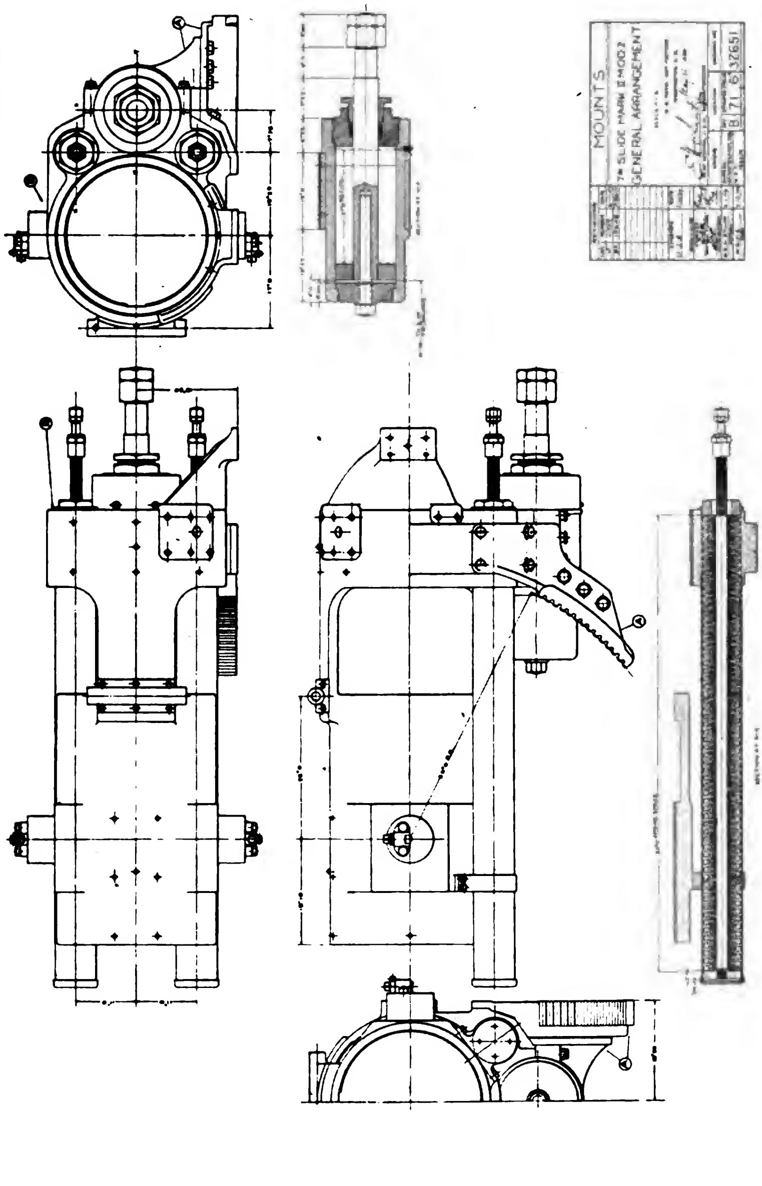


PLATE 81

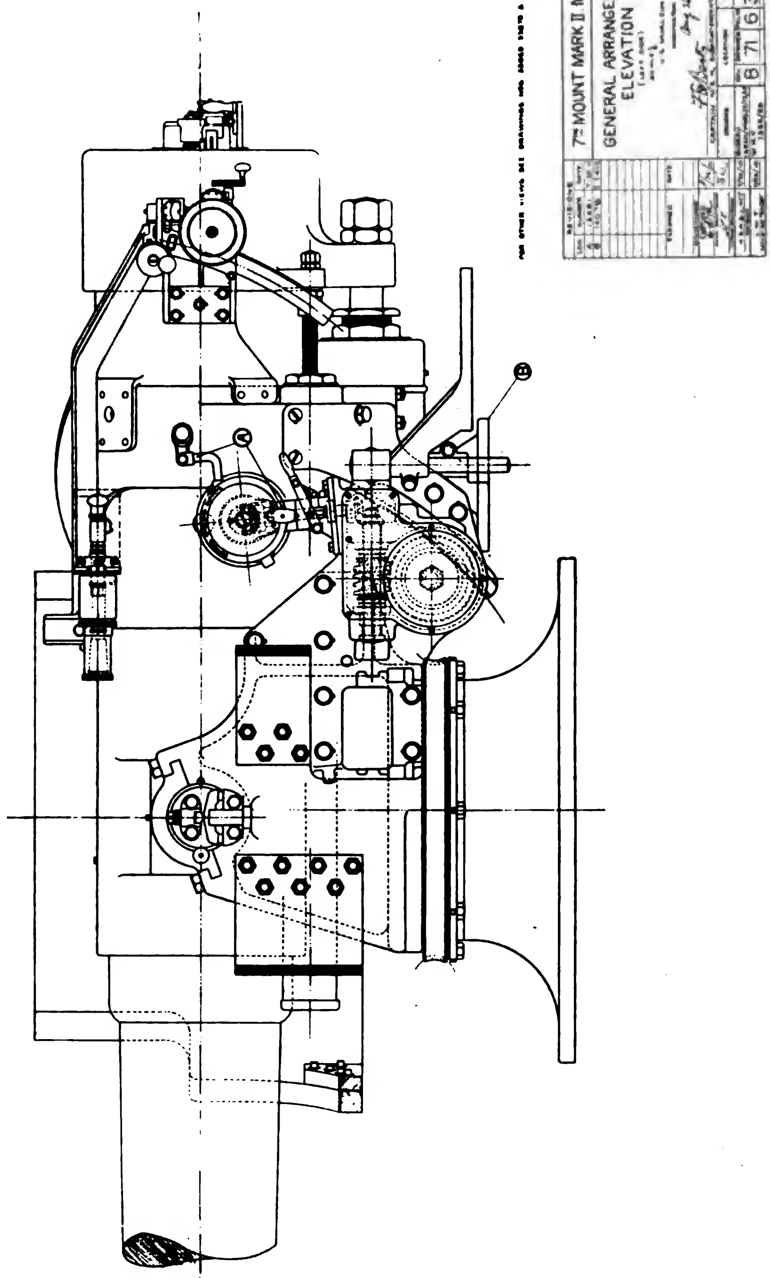

7" MOUNT MARK II. MOD. 3
GENERAL ARRANGEMENT
ELEVATION
B
71
6
35868

PLATE 32

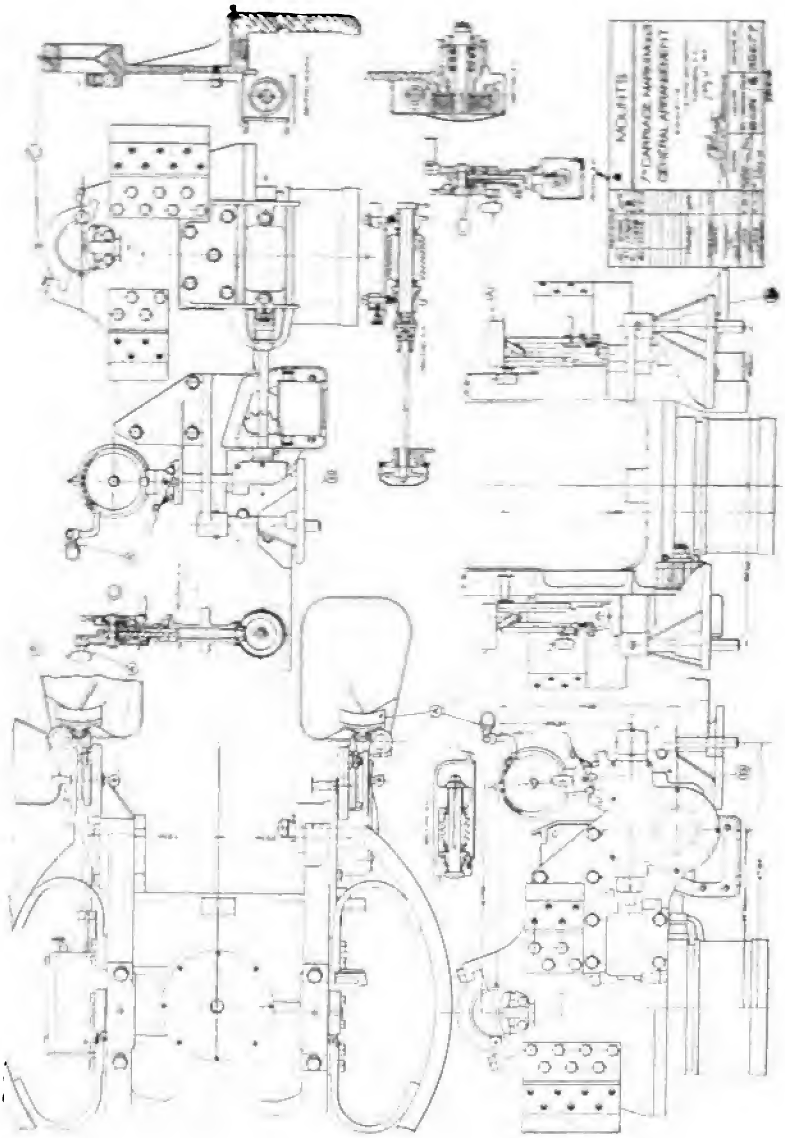


PLATE 83

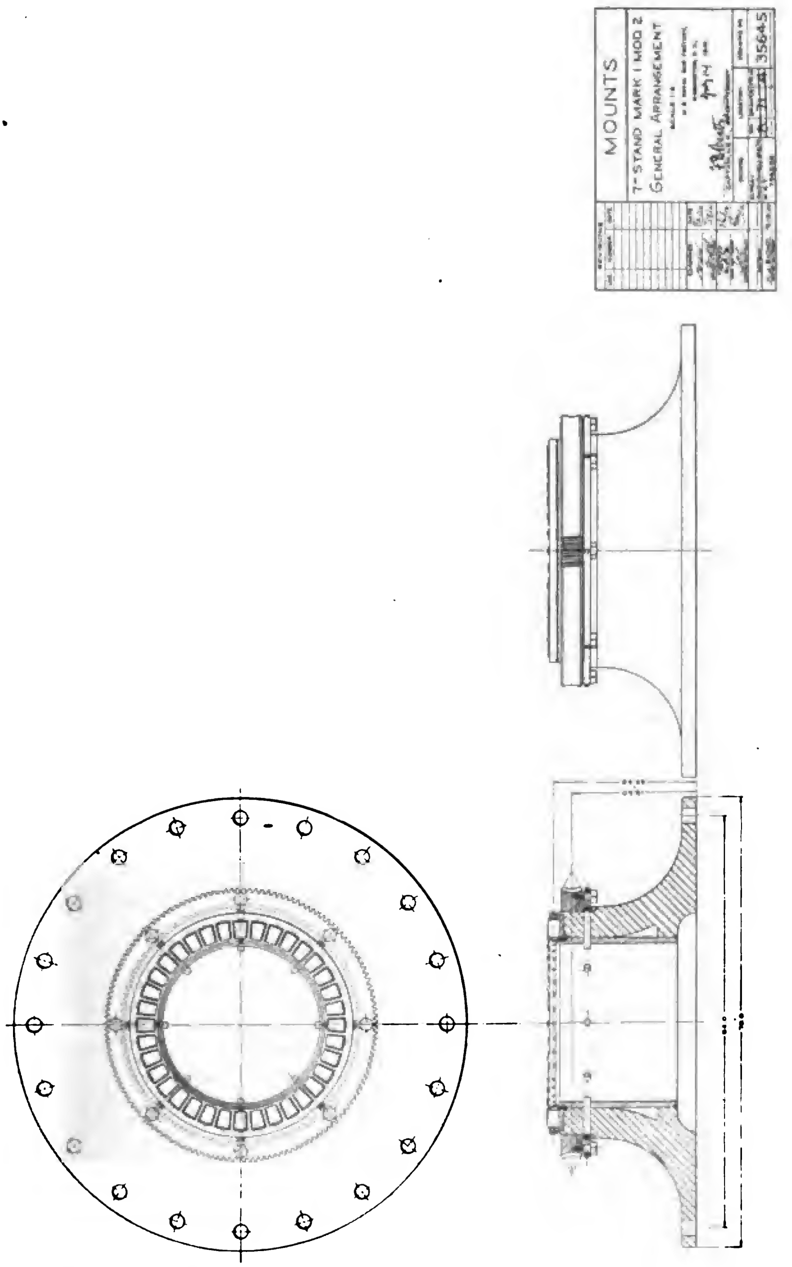


PLATE 84

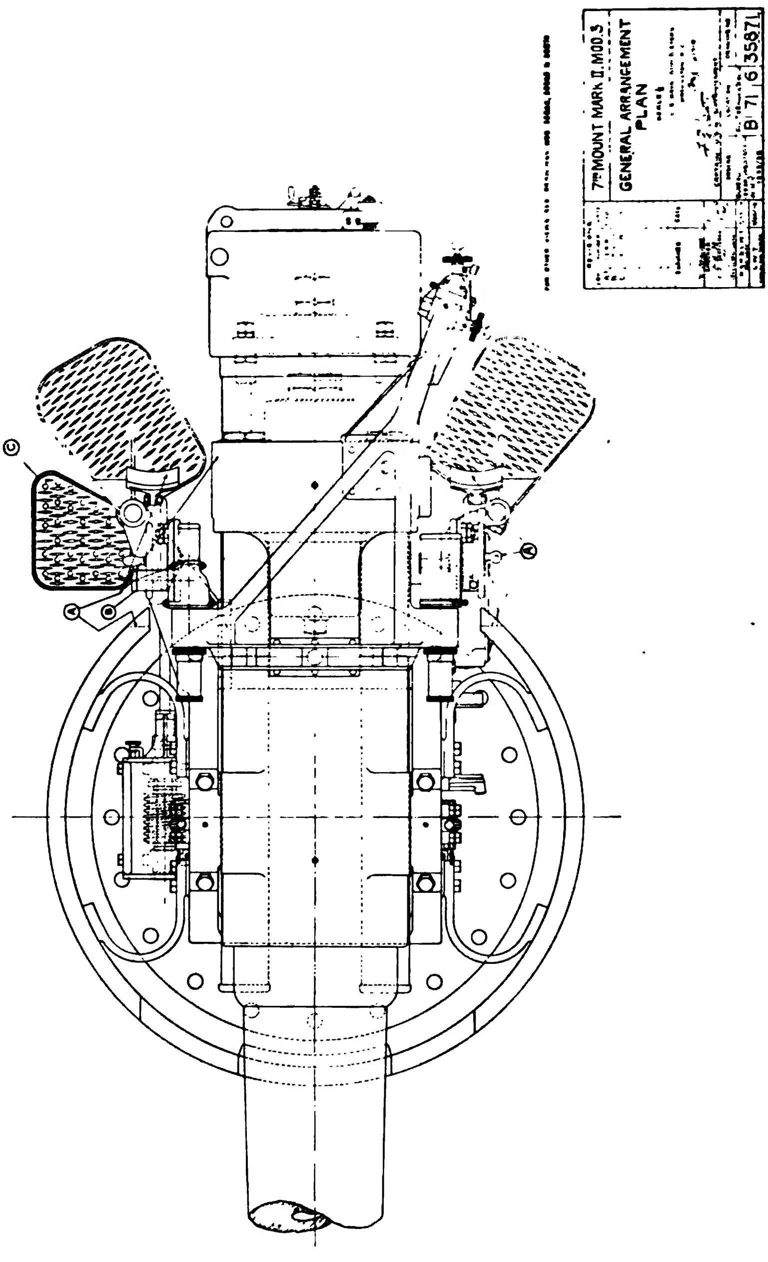
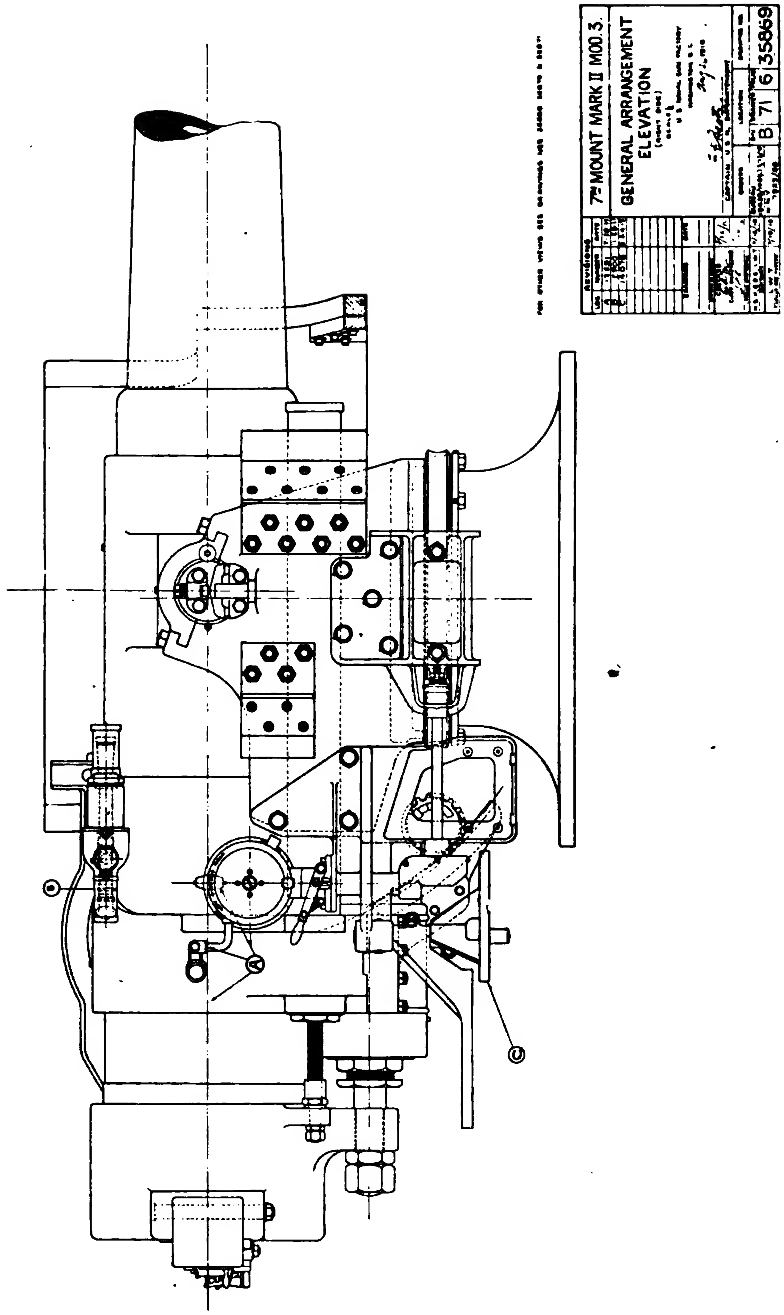
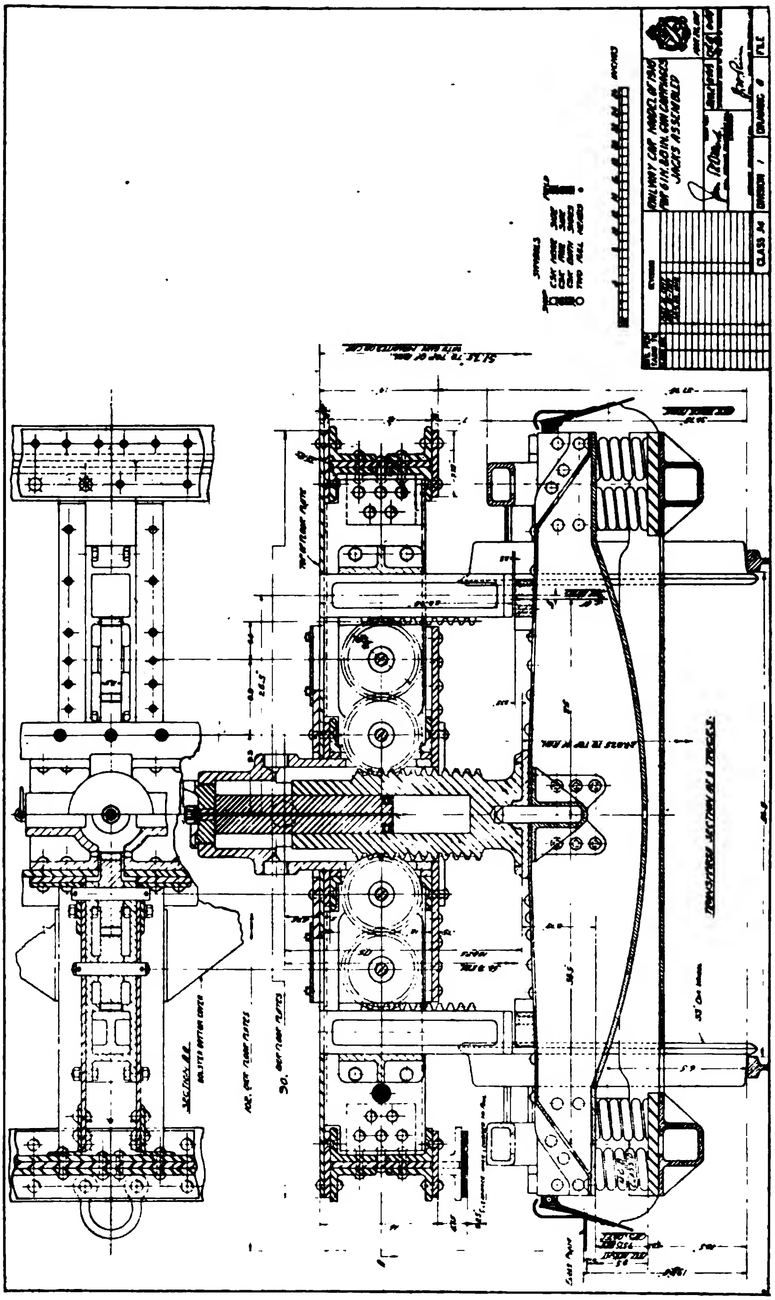


PLATE 85



7" MOUNT MARK II MOD. 3.
GENERAL ARRANGEMENT
ELEVATION
B
71
6
35869
A
B
C

PLATE 86



3.—AMERICAN 8-INCH GUN ON RAILWAY MOUNT. MODEL 1918, M. I. (15)

111. This is a combination of seacoast defense gun and barbette carriage on a special railway car. The mount is shown on plates 88 to 93.

112. GUN.—Seven different types of Army and Navy guns may be used on this mount:

Army guns: Models of 1888, 1888 M.I., 1888 M.II.

Navy guns: Marks I, II, III, IV, (16).

The Army guns are all 32 caliber in length, are equipped with uniform type of breech mechanism and are mounted on model 1918 barbette carriages, having a standard type of cradle with hydraulic recoil and spring return system. The Navy guns vary from 30 to 40 calibers in length, are equipped with four different types of breech mechanism and are mounted in barbette carriages model 1918, M.I. of the same general type as model 1918.

113. RECOIL MECHANISM.—The recoil mechanism as noted above is of the hydro-spring type with one recoil and four spring cylinders arranged symmetrically about the outside of the cradle. Details of this mechanism are shown on plate 94.

114. ELEVATING MECHANISM.—Elevation from zero to 42 degrees is secured through a segmental circular rack attached to the bottom of the cradle. A Hindley worm meshes with this rack. Three sets of bevel gears on as many shafts lead to the handwheel, plate 94. Any thrust due to fire is taken by the worm and transmitted from it to the side frames through the heavy transom casting in which it is mounted. One turn of the handwheel moves the gun through approximately 0.333 degrees in elevation. Details of this mechanism are shown on plate 93.

115. TRAVERSING MECHANISM.—The traversing mechanism provides for a total movement of 360 degrees. The gun and cradle are carried in side frames on a racer casting which is supported by conical traversing rollers. A complete circular rack is mounted on the base ring into which meshes a pinion of the traversing mechanism mounted upon the racer. This pinion connects, through a slip-friction device, a wormwheel and worm and two bevel gears, with the handwheel. The slip friction serves to relieve the gearing from any undue strain from pressure of projectile against lands of the gun in firing. An azimuth circle with pointer is provided for reading changes in azimuth. One turn of the handwheel moves the gun through a little more than 1 degree in azimuth. Details of this mechanism are shown on plate 94.

116. GUN CARRIAGE.—The gun carriage, plate 33, includes the cradle, carrying the recoil and spring cylinders, the elevating and traversing mechanisms, described above, and the cast-steel side

frames, racer and base ring to which these mechanisms are assembled. An operating platform of structural steel is attached to the rear of the side frames and rotates with the gun in azimuth.

117. Railway Car Body.—The railway car body is of structural steel, drop center type construction, with the barbette carriage mounted in the well, plate 92. The body is provided with jack transoms at each end of the well, which mount the four screw jacks used for lifting the body, carriage, and gun for emplacing. French couplers, buffers, etc., were originally provided for service in France, but have since been replaced by the standard M. C. B. type. All of this is shown in detail in plate 92. Air-brake equipment is likewise supplied. French, English, and German railway mounts are not provided with air brakes.

118. Anchorage.—For firing, the car body, carriage, and gun rest upon a firing platform which takes the vertical component of the shock of fire, while the horizontal component is taken by outriggers, plates 88, 89, 30, 95, and 96. The firing platform consists of two lines of H-beams placed under the car, along the railroad ties outside the rails, and of six wooden crossties. The car body is raised by means of the jacks; crossties are then put in place across the top of the H-beams and under the car body and the car is lowered upon them. The outriggers consist of wooden floats about 5 feet square, cast-steel float plates resting against these and serving as sockets for the ball ends of the struts, and struts made of pipe and extending from these plates to suitable attachments on the car body. These attachments are located, four on each side of the car, in such a way that the car can be braced in all directions. The eight floats are placed in as many holes dug in the adjacent ground and the struts are tightened up between them and the car. These floats are located as shown to brace the car horizontally in every direction; details of this arrangement are shown in plate 30. A speed test by a trained crew showed that the car could be emplaced and prepared for firing in 45 minutes and that the emplacement could be taken up and all material loaded on the car in 25 minutes.

119. Trucks.—The trucks are standard 70-ton M. C. B. type having 6 by 11 inch journals and crown cast-steel side frames. The wheels are 33 inches in diameter and are of rolled steel. Both hand and air brakes are provided. Details are shown in plate 97.

120. In addition to the above trucks, a complete set of equipment is furnished for hauling this material over 60-centimeter gauge track. This equipment consists of a gun transport car, plate 98, with loading and unloading rig, a pair of 12-wheel trucks which are substituted for the 70-ton M. C. B. trucks and carry the car body and gun carriage, and narrow gauge shell cars for the ammunition,

plates 99 to 105. Powder, spare parts, tools, etc., are carried on narrow-gauge flat cars.

121. Ammunition Supply System.—A standard-gauge, steel box car with special racks for holding ammunition is provided. This is shown on plate 106. The car has an I-beam trolley, the track of which can be pushed out beyond the end of the car when desired. The ammunition car is located directly back of the gun car, ammunition is run out on its trolley and is dropped on to a loading box located on the after end of the gun car. From there, it is picked up by a small jib crane located on the rear end of the gun operating platform, transferred directly to a second jib crane and by means of the latter swung to the breech of the gun. This method of operation can be employed for angles of fire of 35 degrees or less on either side of the center line of the car. Beyond that, it is necessary to transfer the ammunition to the ground at one side of the car so that it can be picked up by the jib crane. The entire operation of this arrangement is well illustrated on plate 108.

122. Maintenance.—Neither carriage nor car involve any new or uncertain features which might be expected to require extraordinary maintenance. It is perhaps to be anticipated that the car body may, after repeated use in trains, develop a permanent set or sag which would be large enough to necessitate correction. Inasmuch, however, as the mount would probably not be subjected to service either as continuous or as severe as the standard flat car, it is not felt that this should introduce a serious difficulty.

123. Difficulties Involved in Service.—Several minor criticisms in regard to the operation of this mount have developed in connection with experiments made upon it in the United States. Some of these criticisms no longer apply to the mount as it exists now, the design having been modified to correct them, and they are mentioned only to point out what difficulties might have occurred from previously used designs, and to show the development that has taken place.

124. When the car is first fired, the floats yield more or less according to the nature of the ground, and it is necessary to tighten them up or repack the earth behind them. This should not be a serious matter when a large number of shots are fired from the same emplacement in approximately the same direction.

125. The elevating mechanism, before the addition of the antifriction device, was comparatively slow in operation. Somewhat over a minute was required to move the gun through the full arc in elevation or depression, even under the best conditions. This no longer applies, since the antifriction mechanisms have so much reduced the effort required to elevate and depress the gun as to

permit of the use of a gear ratio approximately three times as great as the original.

126. A by-pass pipe is provided from the rear end of the recoil cylinder to the forward end of the recoil buffer. A check valve in this pipe is exposed to severe and sudden pressures on the counter-recoil, and on one occasion during proof it failed to function properly. On investigation, it appeared that this failure to function was due to unsatisfactory machine work, and on paying more attention to the fine machine work of these valves no such difficulty has been experienced on any other mounts.

127. It is difficult to swing the shell away from the breech when carrying it to loading position on the second jib crane. The operation is entirely possible, however.

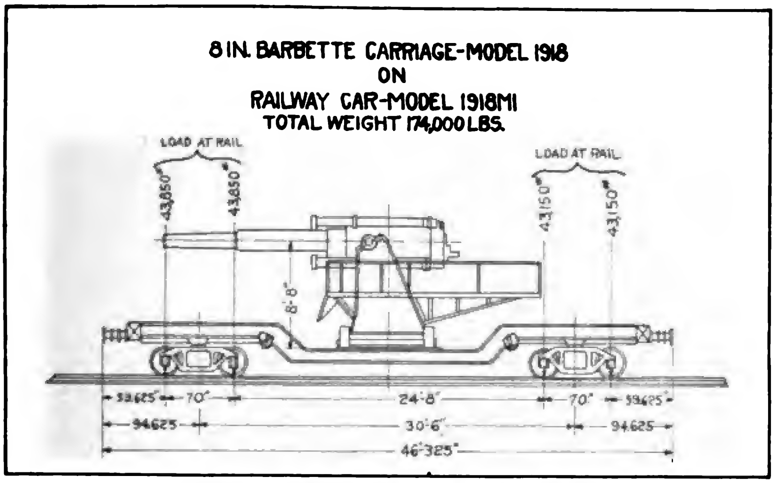
128. The speed test of this mount made by a trained Coast Artillery crew gave a record of four shots in 10 minutes. This is rather slow for the caliber. Since this time, an improved elevating mechanism has been installed, so that it is felt that this record could be bettered.

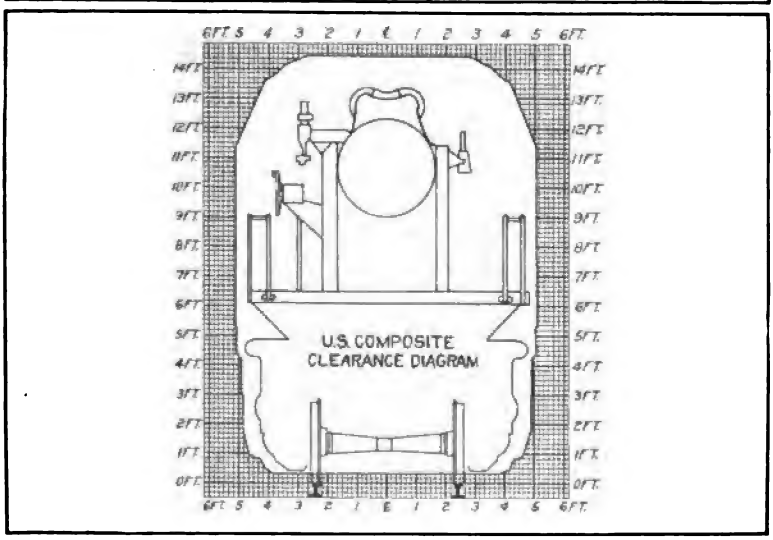
129. Merits.—The one feature which makes this mount conspicuous among railway carriages of all armies and which likely would have made it of very great value in the present war is its system of anchorage. There is no other mount in any of the allied armies which has an anchorage system that compares with this in effectiveness, nor which can be prepared for action in so short a time. The system is self-contained, if this term may be used to state the fact that the anchorage system is a traveling part of the carriage and it is of such a type as to permit the gun to be fired without any difficulty in any direction. To realize the full effectiveness of the efficiency of this anchorage system it should be compared with the anchorage used with the several types of 9.2-inch British guns on railway mounts, the 19 and 24-G French howitzers on improvised all-round traverse platforms, and the 240-millimeter French gun on the railway carriage known as the Colonies type, plate 27.

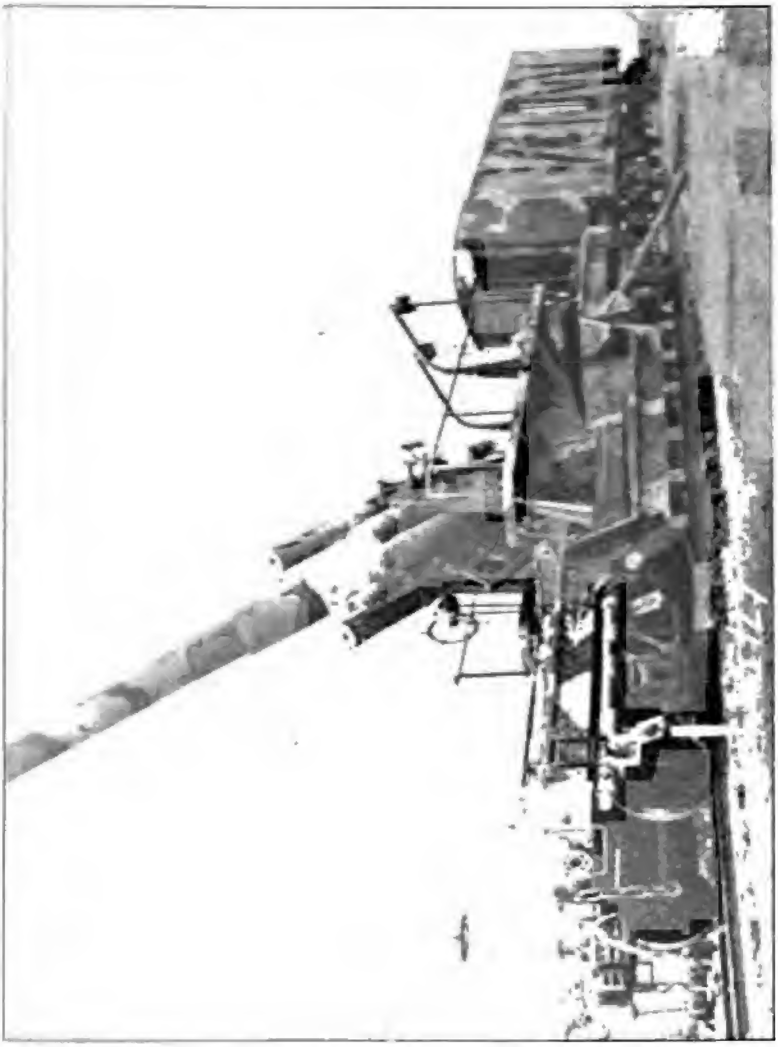
130. Demerits.—The characteristics of the carriage which appear to those who have observed the operation of allied railway artillery as demerits, are as follows: The elevating system includes a rack bolted to the bottom of the carriage meshing with a Hindley worm. It seems certain that under the working conditions that prevailed in the present war considerable difficulty would have been experienced in maintaining this rack and worm in proper working order. Second, a worm of the type of the Hindley worm can not easily be secured in the field, and inasmuch as such a worm must be worn in with the rack, it is possible that some difficulty might have been experienced in the maintenance.

131. A second point which applies perhaps entirely to the mount as originally designed is the lack of rigidity of the underframe. The whip of the car body was so great as to make it impossible for the personnel to remain upon it when the gun was fired. The car body as at present designed, however, has proved satisfactorily sturdy and rigid, and it is probable that there is not sufficient vibration either to injure the barbette carriage, even after long service, or to injure the personnel if they desire to remain on the mount while it is in action.

PLATE 87

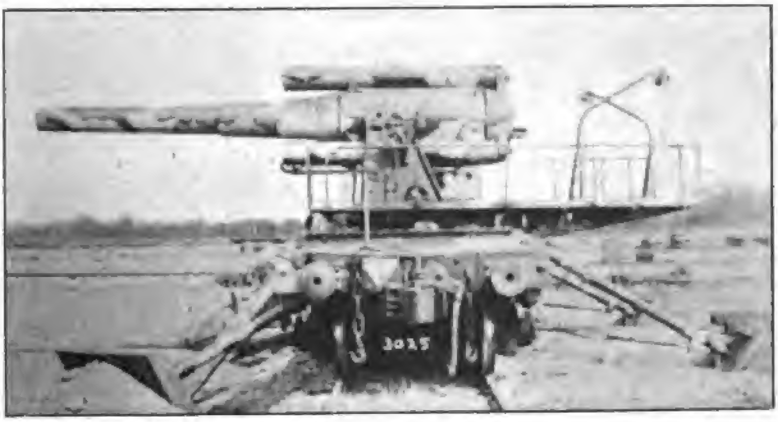


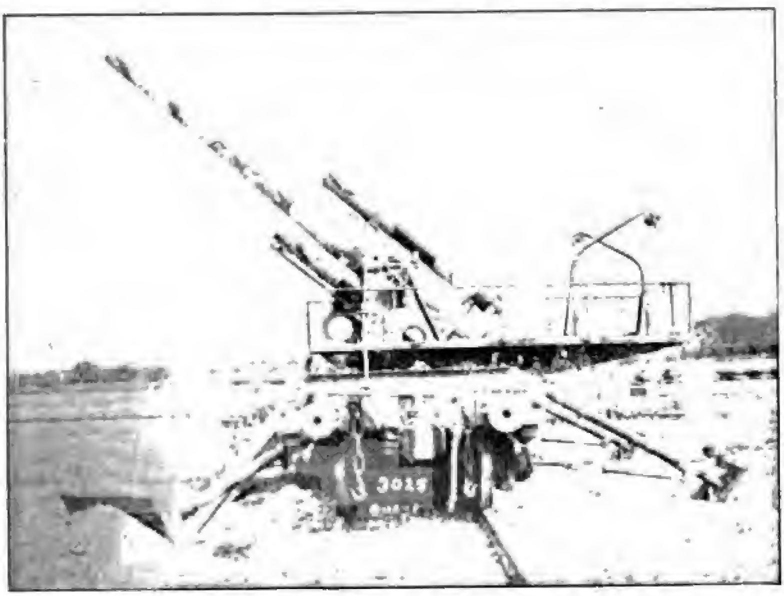




8-INCH AMERICAN GUN ON RAILWAY MOUNT AND STANDARD AMMUNITION CAR.

PLATE 89

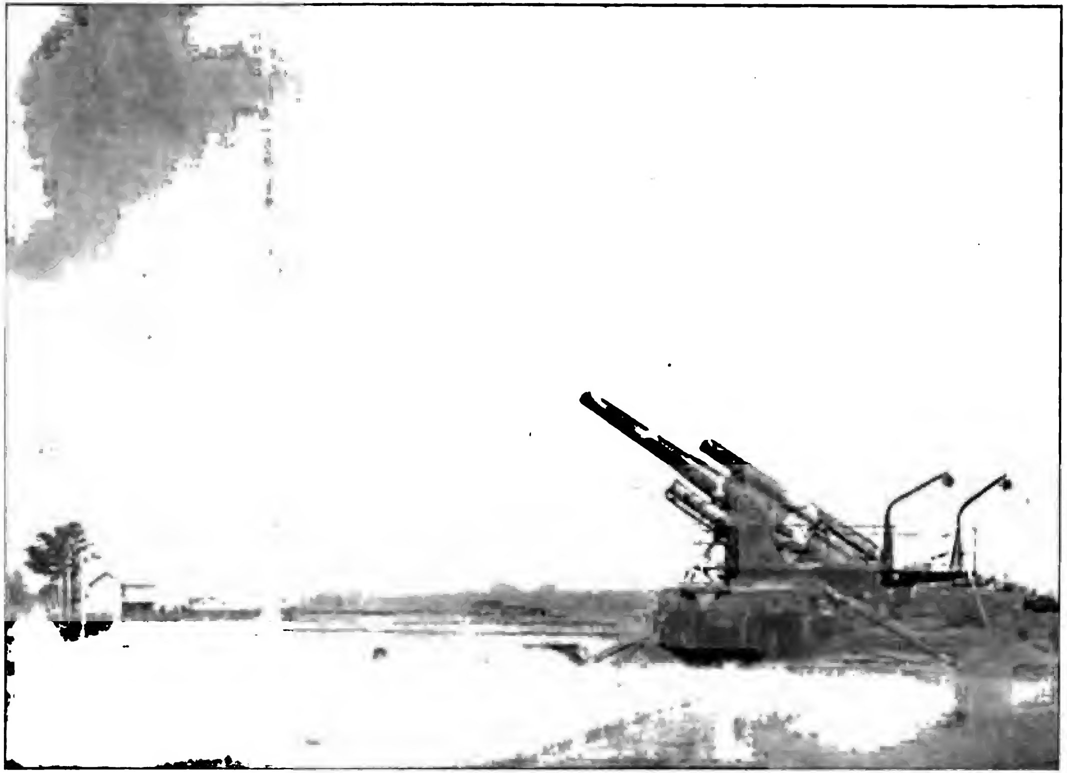




8-INCH AMERICAN GUN ON RAILWAY MOUNT.

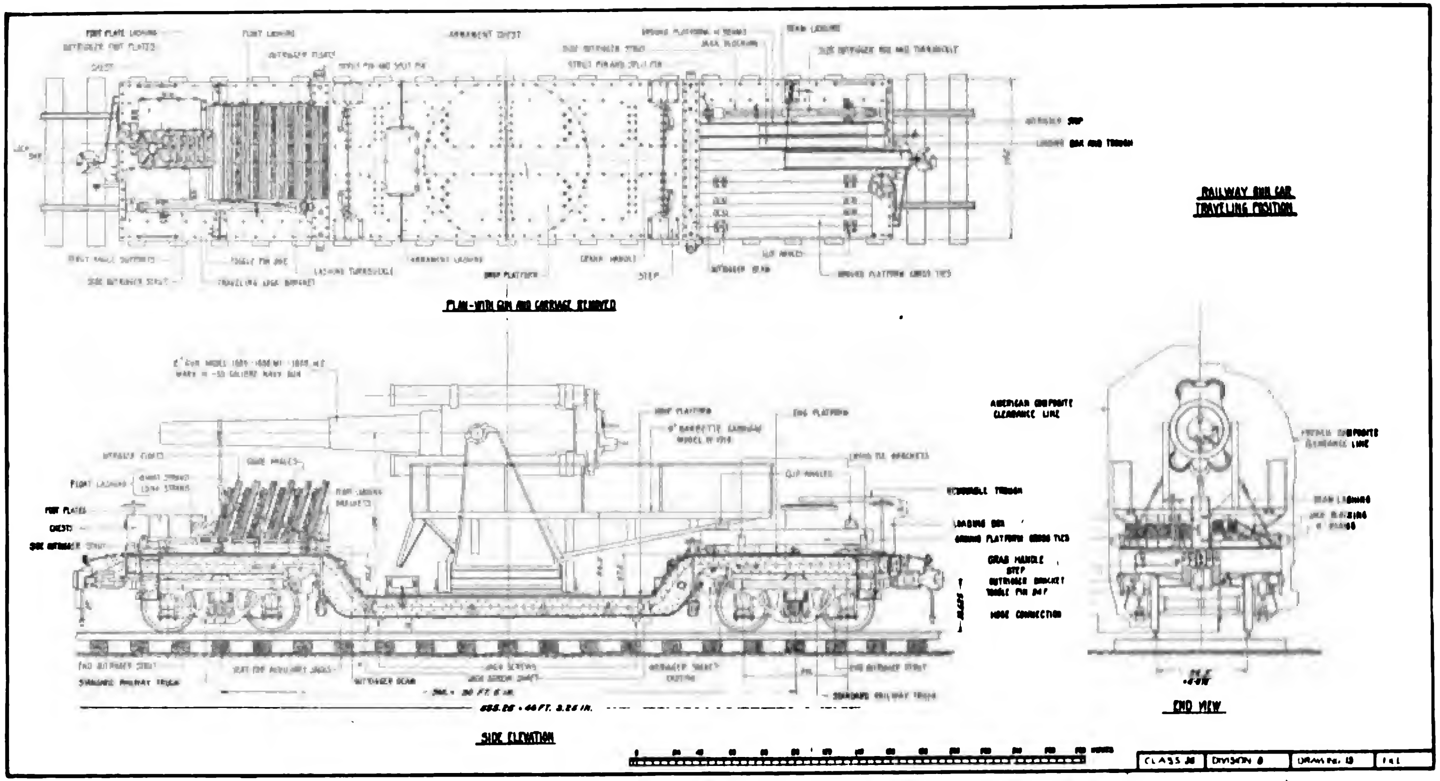
PLATE 90

8-INCH AMERICAN GUN ON RAILWAY MOUNT.



8-INCH AMERICAN GUN ON RAILWAY MOUNT.

PLATE 92



8-INCH AMERICAN GUN ON RAILWAY MOUNT.

PLATE 93

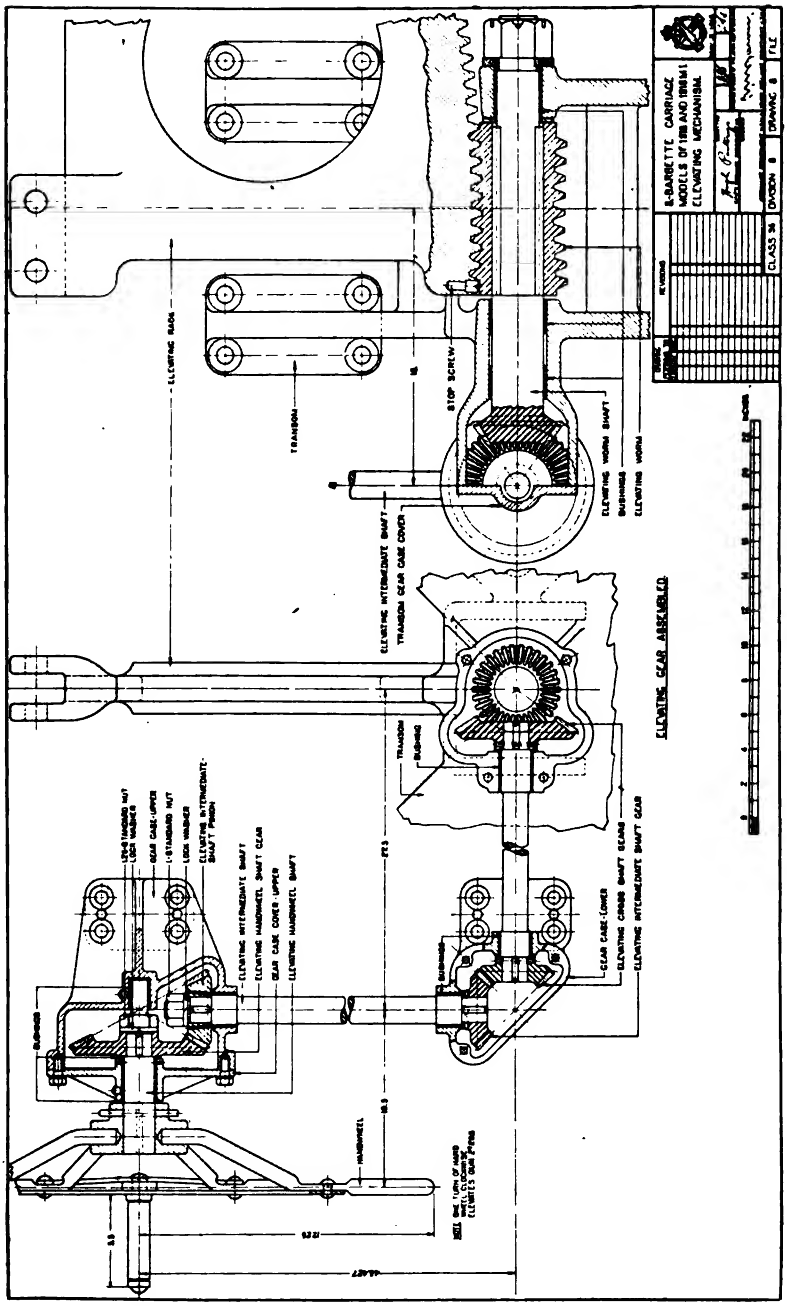
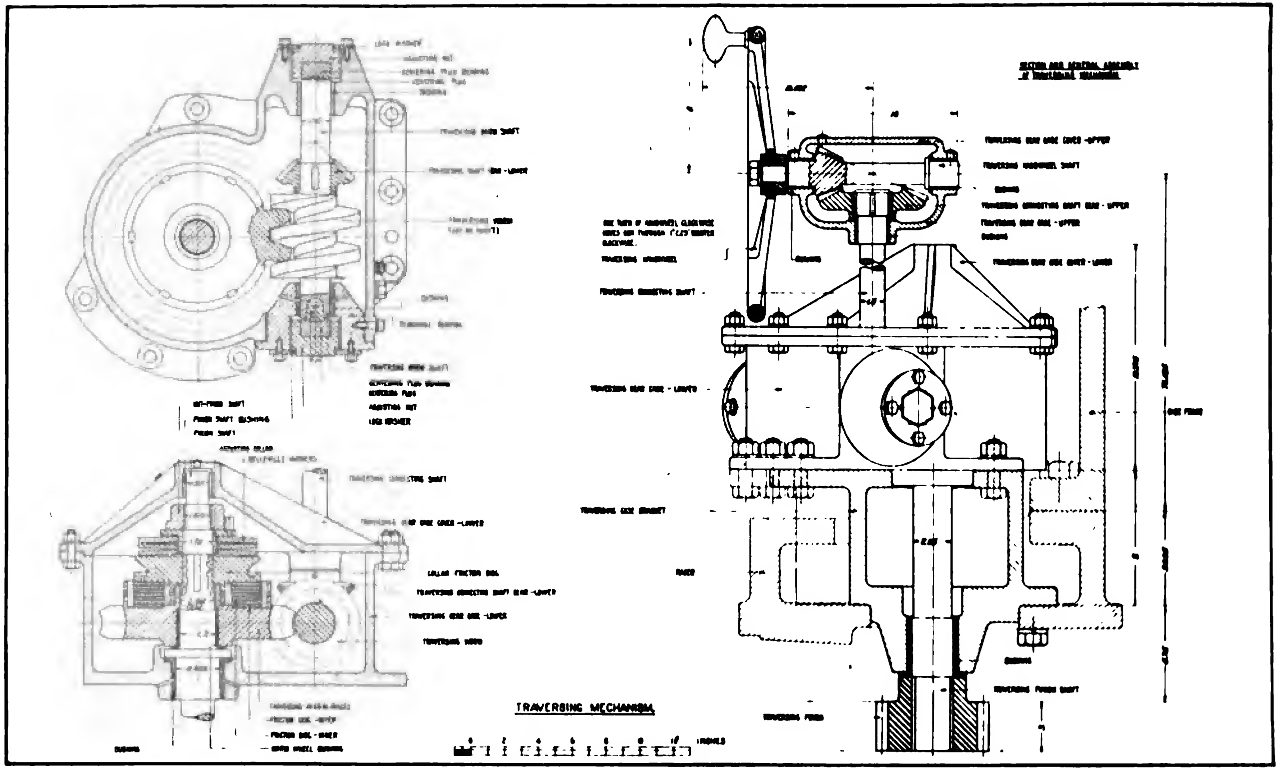
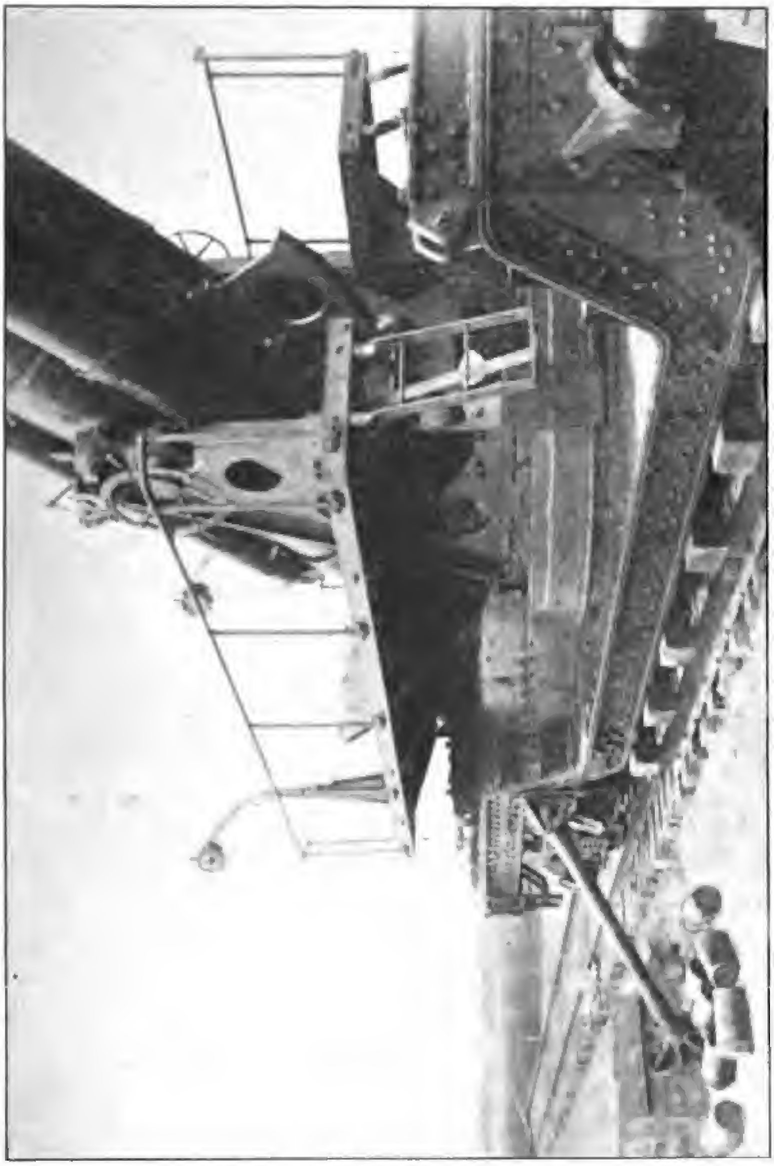

ELEVATING GEAR ASSEMBLED
ELEVATING MECHANISM
ELEVATING RACK
TRANSOM
STOP SCREW
ELEVATING WORM SHAFT
BUSHINGS
ELEVATING WORM
HANDWHEEL

PLATE 94



TRAVERSING MECHANISM OF THE 8-INCH AMERICAN GUN.

PLATE 85



METHOD OF ANCHORING 8-INCH RAILWAY MOUNT FOR FIRING IN DIRECTION OF TRACK.

Plate 96

METHOD OF ANCHORING 8-INCH AMERICAN RAILWAY MOUNT FOR FIRING ACROSS TRACK.

PLATE 97

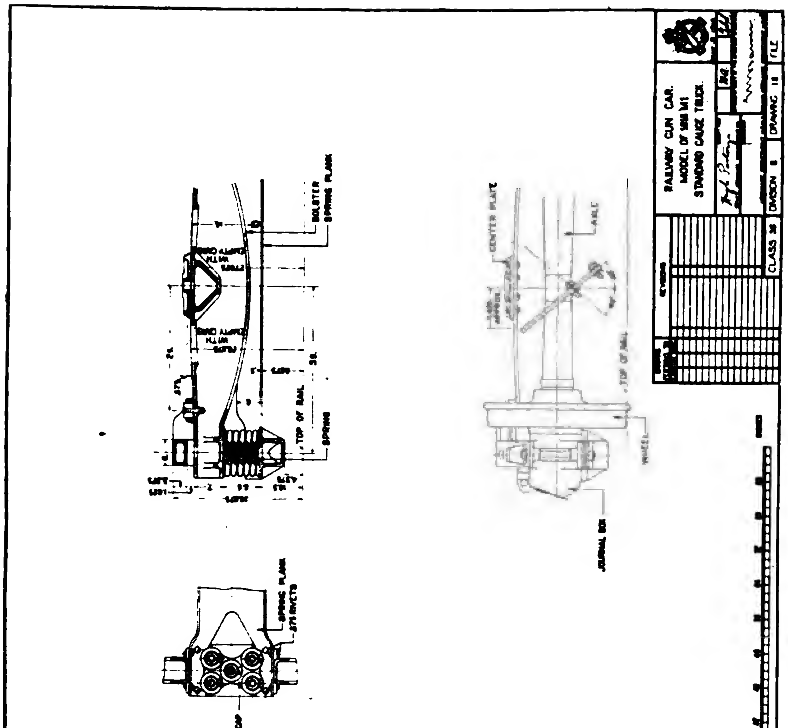

RAILWAY GUN CAR.
STANDARD GAUGE TRUCK.
DEAD LEVER
DEAD LEVER GUIDE
LIVE LEVER
BRAKE BEAM
DEAD LEVER GUIDE FULCRUM
SIDE FRAME
SPRING CAP
SPRING PLANK
BOLSTER
TOP OF RAIL
SPRING
JOURNAL BOX
WHEEL
AXLE
CENTER PLATE
BRAKE SHOE
JOURNAL BOX COVER
LIVE LEVER
TIE BAR

PLATE 98

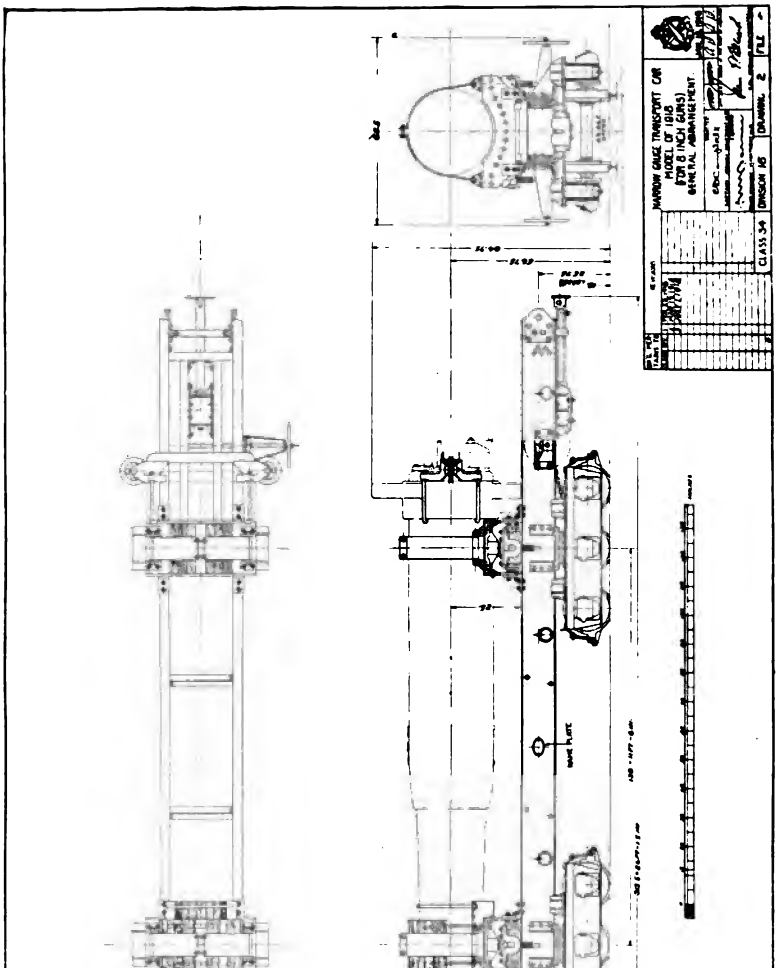

NARROW GAUGE TRANSPORT CAR
MODEL OF 1918
(FOR 8 INCH GUNS)
GENERAL ARRANGEMENT
CLASS 34
DIVISION 15
DRAWING 2
FILE

PLATE 99

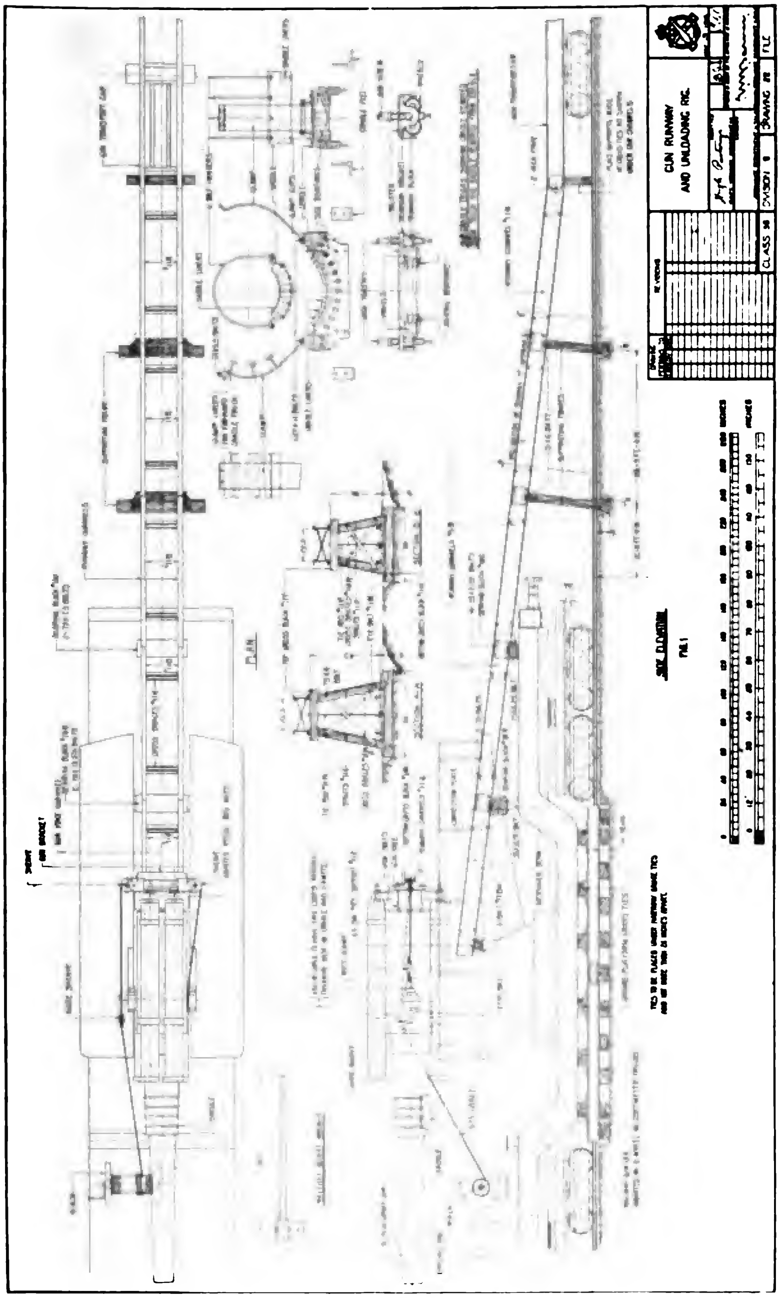


PLATE 100

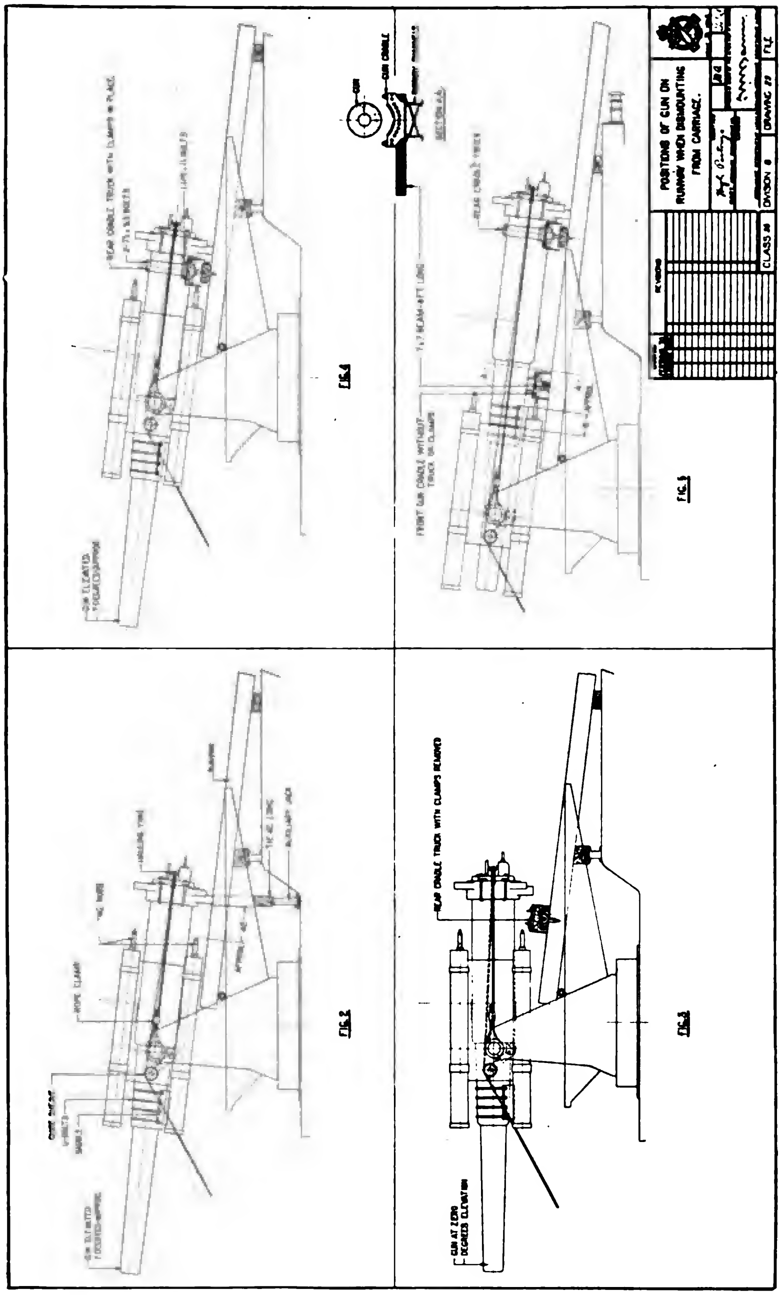

GUN AT ZERO DEGREES ELEVATION
REAR CRADLE TRUCK WITH CLAMPS REMOVED
FIG. 2
FIG. 3
FIG. 4
FIG. 5
POSITIONS OF GUN ON RUNWAY WHEN DISMOUNTING FROM CARRIAGE.

PLATE 101

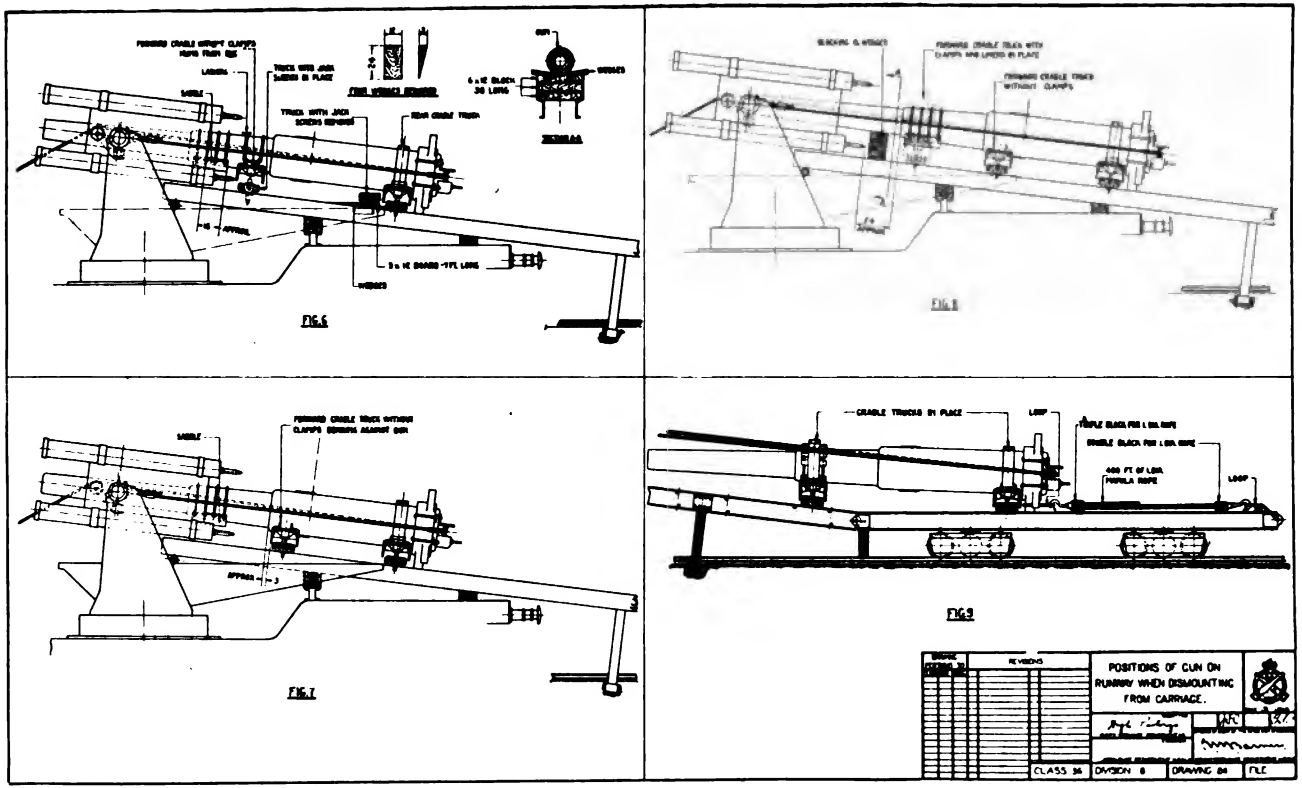

SADDLE
FIG. 6
FIG. 7
CRADLE TRUCKS IN PLACE
LOOP
LOOP
FIG. 9
REVISIONS
POSITIONS OF GUN ON
RUNWAY WHEN DISMOUNTING
FROM CARRIAGE.
CLASS 36
DIVISION 8
DRAWING 84
FILE

PLATE 102

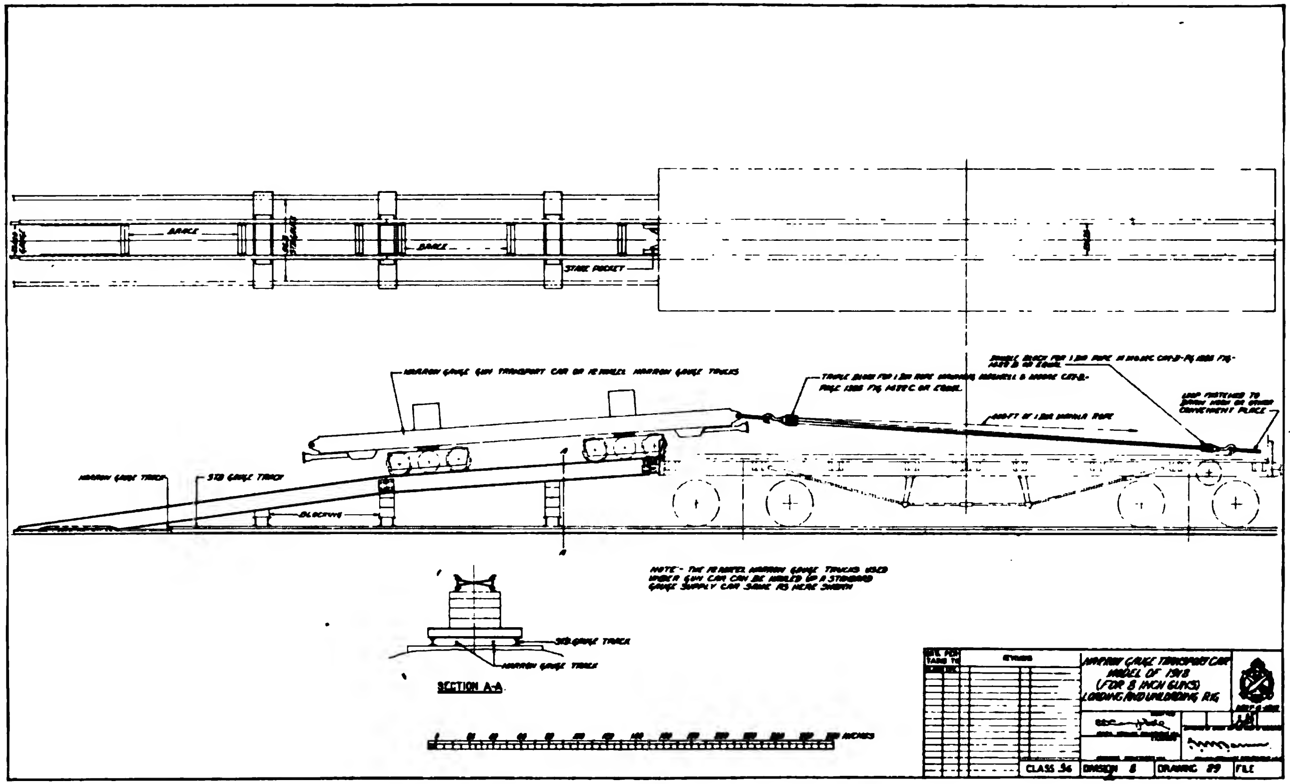

NARROW GAUGE TRANSPORT CAR
MODEL OF 1918
(FOR 8 INCH GUNS)
LOADING AND UNLOADING RIG
CLASS 56
DIVISION 8
DRAWING 89
FILE
STAKE POCKET
GAUGE
STD GAUGE TRACK
NARROW GAUGE TRACK
BLOCKING
SECTION A-A
INCHES

PLATE 103

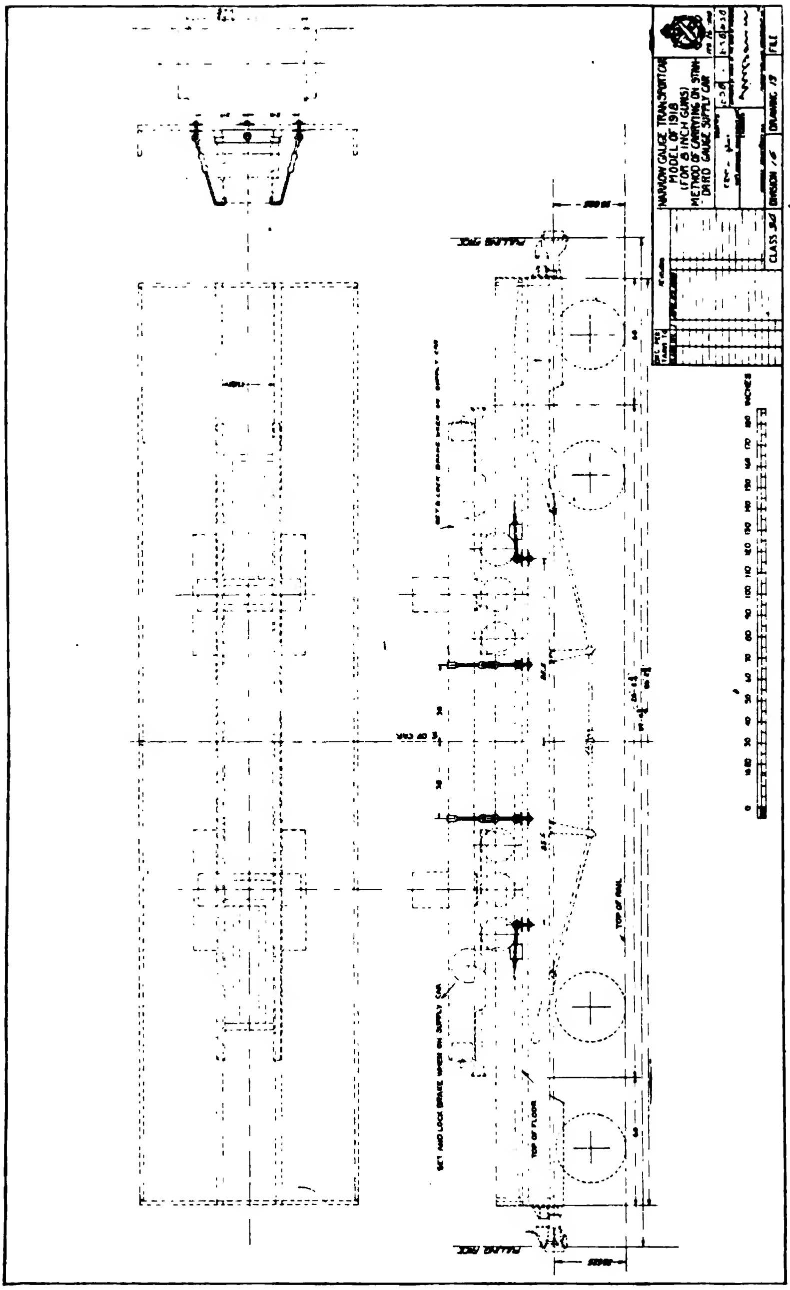

NARROW GAUGE TRANSPORT CAR
MODEL OF 1918
(FOR 8 INCH GUNS)
METHOD OF CARRYING ON STANDARD GAUGE SUPPLY CAR
TOP OF FLOOR
TOP OF RAIL
INCHES

PLATE 104

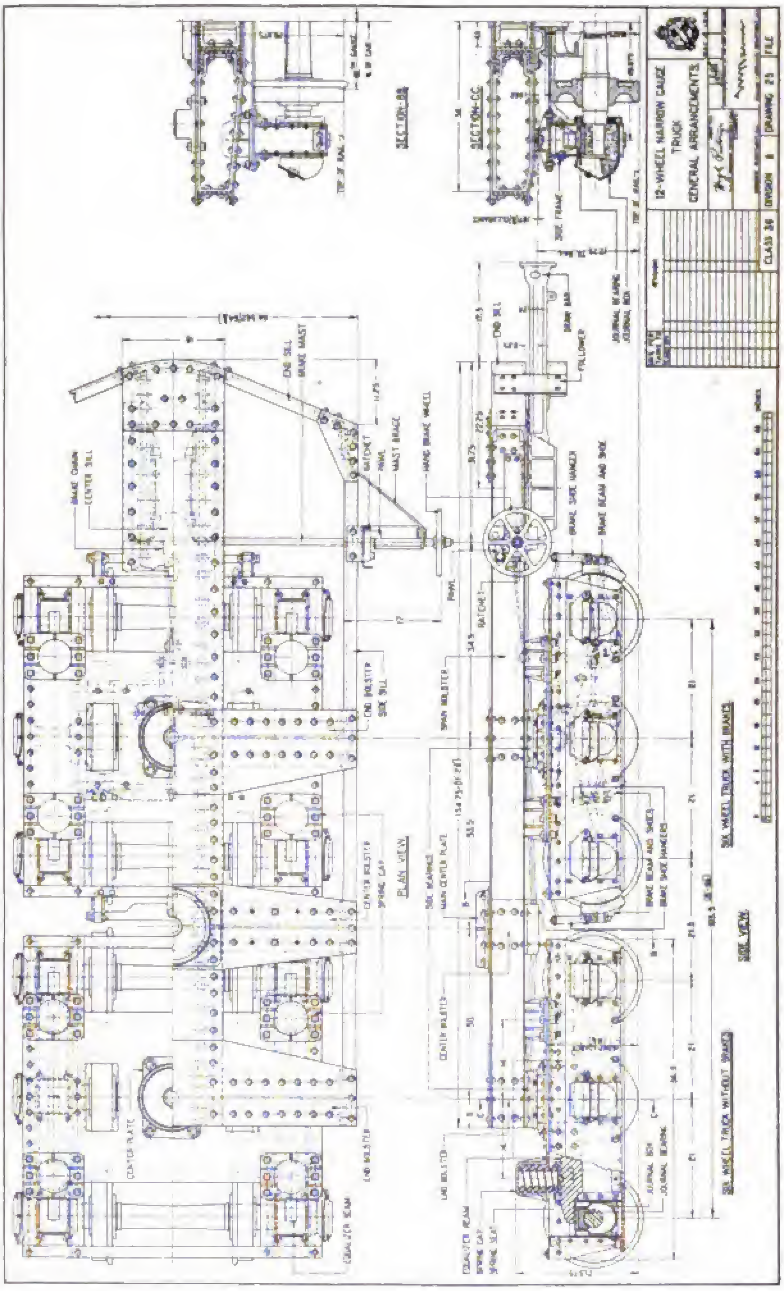

12-WHEEL NARROW GAUGE TRUCK
GENERAL ARRANGEMENTS
PLAN VIEW
SIDE VIEW
SECTION-BB
SECTION-CC
SIX WHEEL TRUCK WITH BRAKE
SIX WHEEL TRUCK WITHOUT BRAKE

Plate 105

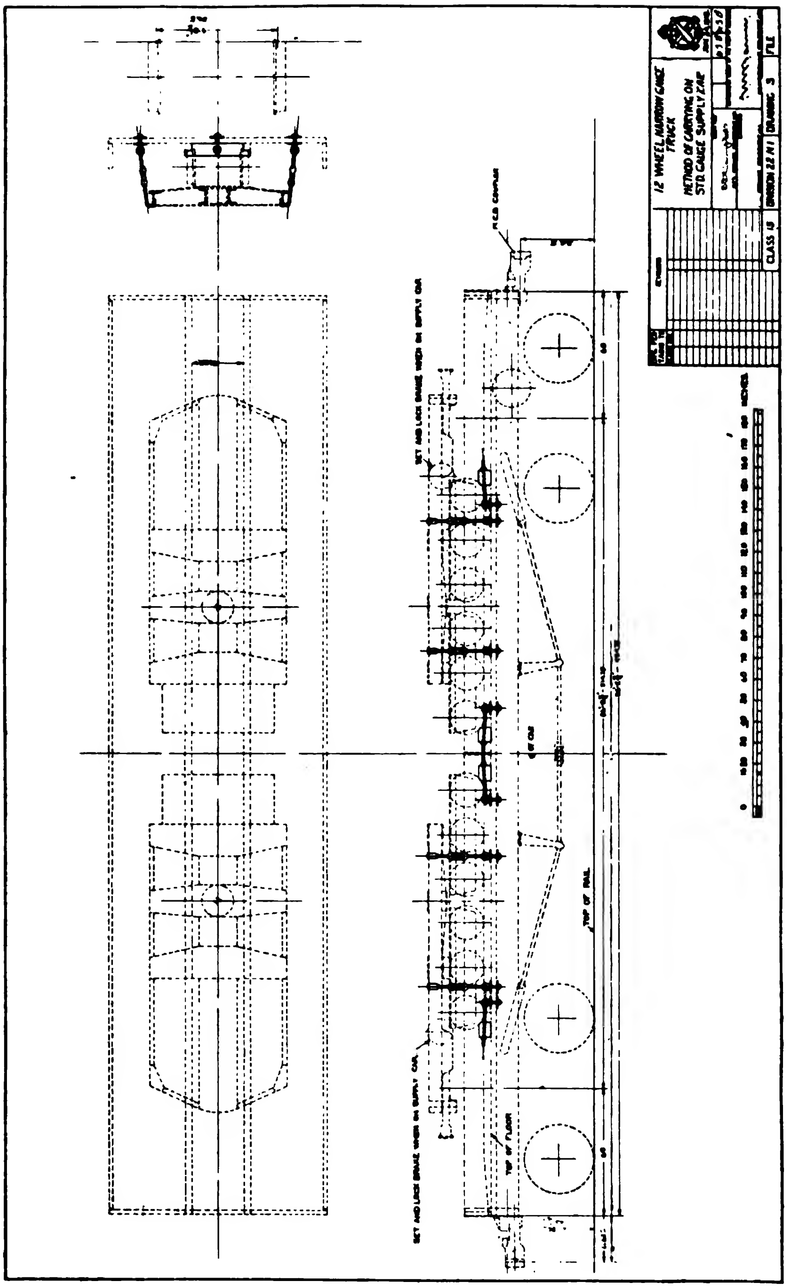

12 WHEEL NARROW GAUGE TRUCK
METHOD OF CARRYING ON STD. GAUGE SUPPLY CAR
CLASS 19
DIVISION 22 N1
DRAWING 3
FILE
M.C.B. COUPLER
SET AND LOCK BRAKE WHEN ON SUPPLY CAR
TOP OF FLOOR
TOP OF RAIL
INCHES

PLATE 106

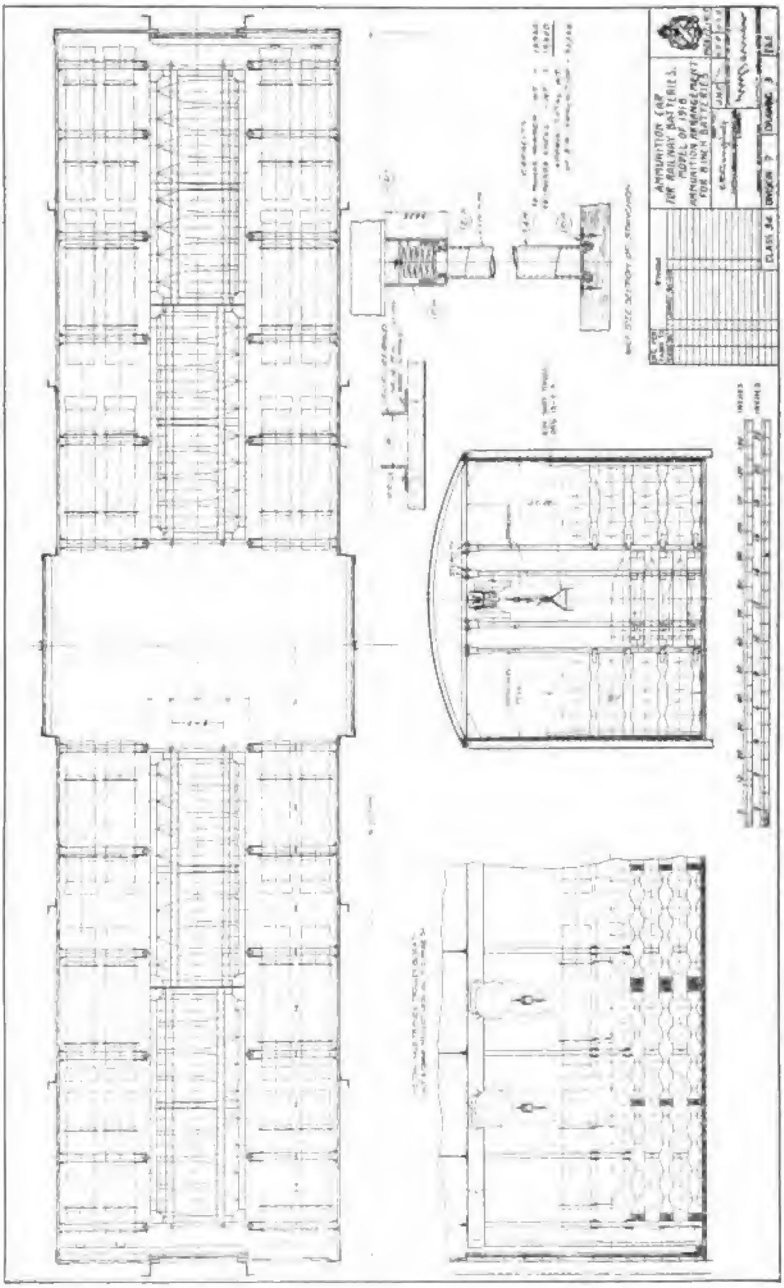
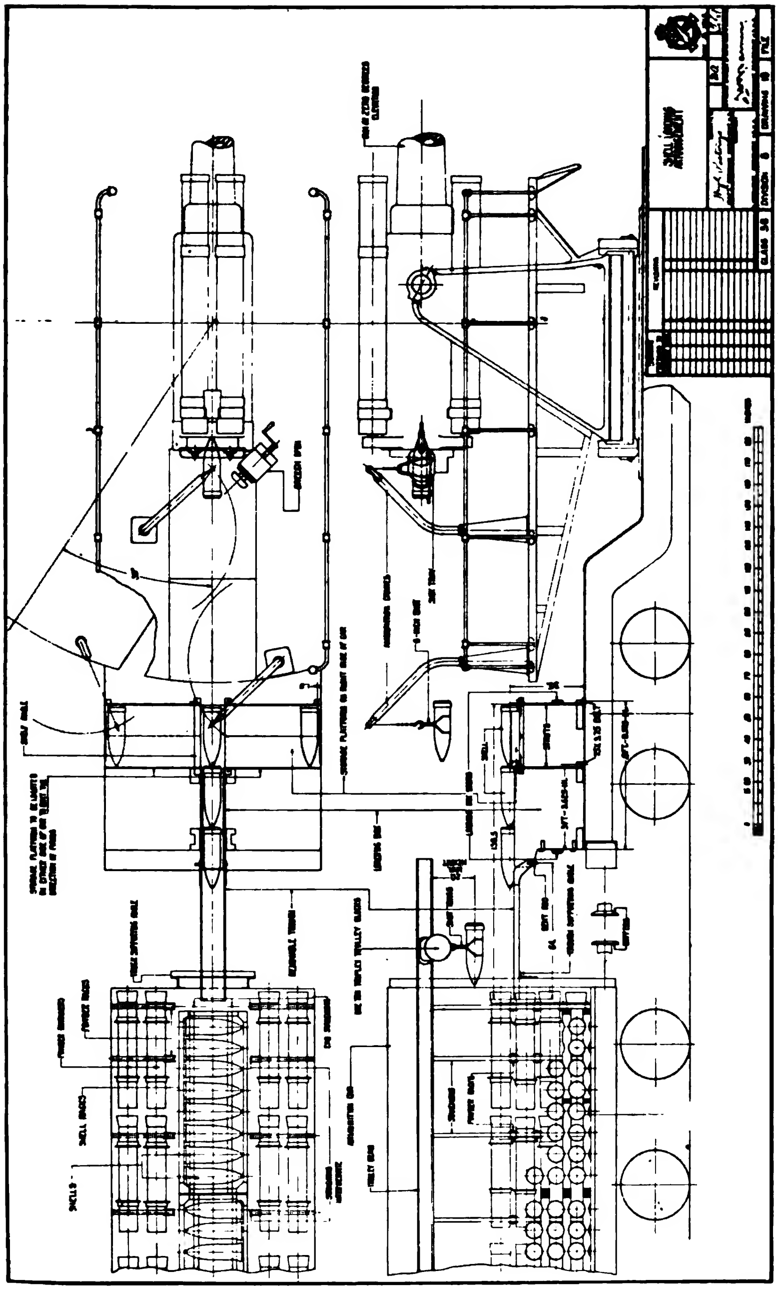

AMMUNITION CAR
FOR RAILWAY BATTERIES,
MODEL OF 1918
AMMUNITION ARRANGEMENT
FOR 8 INCH BATTERIES
CLASS 34
DIVISION 7
DRAWING 3

PLATE 107



4.—AMERICAN 10-INCH GUN ON SLIDING RAILWAY MOUNT.(17)

132. These guns are mounted on what are termed "sliding mounts" in the American and English Armies, and "glissement mounts" in the French Army. The gun is swung directly by means of its trunnions, in bearings mounted rigidly on the side girders of the car body, and the gun and mount slide back together along the track in recoil. The mount is stopped by the friction between the special jacking beams or sleepers in the bottom of the mount and special firing beams or I-beam stringers attached to the ties of the track. Most mounts of this type have no internal means of traversing the gun with respect to the car body or the trucks, and they must be operated on curved tracks to train the gun in azimuth. This is the first modern mount of this type to be described and it may be of interest to mention some points with reference to its development. It will be recalled that in the "Historical introduction," mention was made of the 13-inch mortar mount constructed and operated by the Union Army, in which case the gun carriage slid on rails on top of the car and the car rolled back on the track when the gun was fired.

During the interval between the Civil War and the present war, several proof mounts were constructed by various countries, operating on the same principles, but at the beginning of the present war no nation had constructed for itself any railway mounts on which provision had been made for dissipating the energy of recoil by means of friction between special mechanisms designed as a part of and constructed into the car body and the railway track. The only railway mounts that the French Government possessed at the beginning of the war were some 200-millimeter mounts which the Schneider Ordnance Co., had constructed for the Peruvian Government and which had not been delivered. The designers of the various French ordnance companies were hard put to design carriages on which their heaviest seacoast guns could be mounted and which could be constructed with the facilities available in a satisfactorily short period of time. The scheme of mounting the gun rigidly in the carriage and permitting the mount to slide back on the track in recoil was developed by the Schneider Ordnance Co., late in 1914, and the first carriage mounting a 320-millimeter gun was proved at their heavy artillery camp in February or March, 1915. The designers had considerable misgivings with reference to the performance of this carriage, which had not been developed through any slow process of evolution; but the exhaustive test to which this first carriage was subjected soon proved that although it might appear to be a crude mechanism it nevertheless was unusually sturdy and the gun could be operated as rapidly and as accurately as any other gun provided with the most elaborate of recoil mechanisms and accessory equipment. The French Government then proceeded to mount as rapidly as possible a great number of their large guns on carriages of this type.

133. It is very significant that none of the nations engaged in the present war used any great number of large guns, if any at all, that were finished after their entrance into the war. The writer knows of only two guns finished and mounted by any of our allies, on railway carriages, since 1914. All other guns mounted were either in storage, or were removed from battleships or coast fortifications. On the entrance of America into the war, it was discovered that the supply of guns of some of our allies was running dangerously low and it was proposed that we supply them with some of our heavy guns. Fifteen of the 10-inch guns of the model that are being mounted on these carriages, were sent to France in September or October of 1917, to serve as a reserve and at about the same time, it was decided to have the French Government construct 36 new mounts for more 10-inch guns which would be sent across. Shortly thereafter, the French Government found that its manufacturing facilities would not permit it to supply all of the material for these mounts, as well as to construct them, and plans were made to have the plates, castings and forgings supplied, cut to shape and rough machined in America, and assembled in France in the shops that had been constructing the 320-millimeter sliding mounts.

134. The first four sets of these parts arrived in France several months before the signing of the armistice and were in process of fabrication at the time of the signing of the armistice. It was planned to have most of the mounts finished and ready for service for the big offensive that was planned for the spring of 1919. Several months after the armistice was signed, the four sets of parts that had arrived in France were shipped back and plans were made for completing the mounts in America. Many of the details of design have since been changed and it is probable that only a limited number of the mounts will be constructed. In considering this type of mount from many standpoints, it should be understood that it was originally designed under the stress of the most desperate need and was not chosen because it was the finest possible carriage on which the guns could be mounted. It proved most commendably sturdy and served its purpose well in the type of warfare for which it was designed. General views of the design that will be described are shown on plates 109, 110, and 111.

135. Gun.—The guns to be used with this mount are the 10-inch models of 1888, 1888 M. I., 1888 M. II. and 1895, all of 34 caliber

length, and eight different models of Navy guns from 30 to 34 caliber length. All of these guns are provided with fixed trunnions. All of the Army guns are provided with interrupted thread breech blocks and the Navy guns with stepped thread blocks. All of the breech blocks are fitted with mechanical firing mechanisms. All of the Army guns are rifled with 60 grooves and the twist of the rifling is to the right, progressing in pitch from 1 turn in 50 calibers to 1 turn in 25 calibers.

136. Recoil Mechanism.—No recoil mechanism in the ordinary sense of the term, is provided with this type of mount. The gun is fixed to the girders as already noted, and the entire mount slides back along the track as a unit under the shock of recoil. A description of the mechanisms employed to bring the mount to rest, is given under the head of "Anchorage." Counter-recoil is accomplished by the same mechanism that is used in traversing the mount. The length of recoil averages 1 meter.

137. Elevating Mechanism.—Provision is made for elevating the gun from minus 7 degrees, the loading angle, to plus 54 degrees. This provision of so great an elevation, that prior to 1917 would have been considered entirely unwarranted, has come about through our experiences in this war. No one is now certain of what constitutes a proper line of demarkation between a gun and howitzer, and no one can be certain either that within a comparatively short time we may not find it profitable to operate all guns, as well as howitzers, at these extreme elevations. The elevating rack is bolted to the right side of the gun, plates 110 and 111. The pinion meshing with the rack is connected with the handwheels provided on both sides of the carriage through a slip-friction device, plate 113, a worm-wheel, worm and bevel gears. One revolution of the handwheel moves the gun through 1.37 degrees in elevation. To reduce the effort required in elevating and depressing the gun, anti friction devices have been provided on each trunnion. The design of these devices is shown on plate 114. This is a design of antifriction device, that to some extent has been taken from French railway mounts, but has been modified and improved. It has been used already on several other railway mounts and has proved particularly efficient.

138. Traversing Mechanism.—Since the gun is mounted rigidly in the car body and it is not possible to move the car body with respect to the trucks, it is necessary to move the entire mount along a curved track to train the gun in azimuth. The procedure in preparing these curved tracks has been described in other portions of the report. The mechanism used in moving the mount along the track is

termed a translating mechanism and is incorporated in the front truck. Gear cases and two handles are constructed on both sides of the front truck as shown on plate 109. Sprocket wheels on the cross driving shaft of this mechanism are connected with sprockets on two axles, as shown on plate 117. A clutch is provided by which the mechanism can be thrown out of gear for firing, and for traveling it is necessary to remove the chains. It is possible for four men to move the mount along the track by means of this mechanism at the rate of about a meter per minute. The ratio is 117 turns of the handle for one revolution of the car axle.

139. Gun Carriage.—The gun carriage is incorporated in the car body and will be described in the next paragraph.

140. Car Body.—The car body is made up of two structural steel box girders connected by deck plates and a series of structural steel transoms. The jack screws required for the operation of the jacking beams, the elevating mechanism and the loading mechanism are all incorporated in this structural steel body. The success of this type depends upon the car body being given a rigidity approximating as closely as possible that of a steel casting. As a consequence, it is necessary to have the web plates of all the transoms come into contact with the web plates of the side girders and to have the seats for all of the fittings carefully and accurately machined. The rivetting must likewise be well nigh perfect.

141. Anchorage.—The only anchorage with which this mount is provided, is the friction between the sliding beams and the I-beam stringers or firing beams attached to the ties. The I-beam stringers are placed on the firing track or epis, as shown on plate 118. When the gun has been properly trained in azimuth by moving the mount along the track by means of the translating mechanism already described, the six sleepers shown in their relative position on plate 109, and in detail on plate 119, are forced down on these firing beams as hard as a man on each of the ratchet levers is able to force them. The design of the jackscrew and operating mechanism is shown on plate 117. The men operating these jacks run the sleepers down by means of the handles, first giving the handles one full turn at a time at the call of a sergeant, until the sleepers come into contact with the beams. Then they turn the handles through half revolutions in concert, as long as they are able to turn them. The final tightening is done by means of the ratchet levers and is likewise performed in concert at the call of the sergeant in charge. These jacks normally take about one-half of the entire dead load of the mount and practically all of the firing load. When the gun is fired the entire mount slides back on the stringers, an average distance of one meter. The

jacks are then released, all of the men working in concert as in tightening, and the mount is returned to its firing position by the translating mechanism. In the various actions by this type of artillery that the writer has observed, no cases were seen in which the rate of firing was limited by the time required to return the mount to its firing position and place the jacks. The time required for loading the gun was always the determining factor in the rate of firing.

142. Trucks.—These mounts are provided with two special 6-axle trucks with 5.5 by 10 inch journals and 36-inch wheels. The truck frames are of structural steel and the axles are equalized in groups of three. The design of these trucks is shown on plates 120 and 121. Spring-supported conical rollers of a design shown on plate 122 are provided between the trucks and the car body to serve as side bearings.

143. Ammunition Supply System.—The ammunition car that is to be used with this mount is identical with that provided for the 8-inch railway mount, but with modifications in the fixtures to take the 10-inch ammunition. This car is shown on plate 123. With French mounts it was customary to transfer the ammunition from the ammunition car to the mount by means of a shuttle car known as a transbordeur. No shuttle car is provided with this 10-inch mount; instead, a track is provided on the rear truck with an extension made up of two hinged wings, plate 125, which carries a shot truck onto which the projectile may be laid from the trolley of the ammunition car. Provision is made on the truck just back of the mount, plate 124, for storing four projectiles, two on either side of the track. Two identical jib cranes are provided on the rear of the mount, plate 124, and of a design shown on plates 125 and 126, by means of which projectiles may be picked up from the rear or from the side and placed on the tray of the loading stand. This loading stand is of an entirely new design and is collapsible for traveling. The details of its design are shown on plates 127 and 128. The loading angle is minus 7 degrees and when the projectile is given a start down the greased tray it acquires sufficient velocity to ram itself. In the top view, plate 124, there are four doors in the deck of the mount, between the two crane pedestals. These are doors to four asbestos-lined powder-storage boxes in which sixteen charges of powder can be stored with little probability of change in temperature within a reasonable time or danger of ignition from fire.

144. Maintenance.—The French and American personnel operating these mounts in the field, found them most satisfactory from the standpoint of service. The mounts were exceedingly sturdy and there are few mechanisms requiring much attention. The oiling of

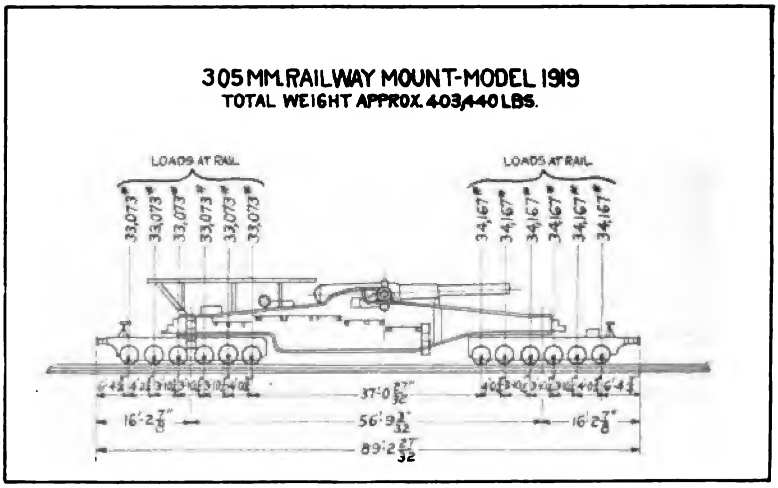
the jacks, truck bearings, trunnion bearings, breech mechanism, etc., is about the only maintenance that this type requires.

145. Difficulties Involved in Service.—The one difficulty that may be laid to this mount in service is the time required for the laying of a new firing track and occasionally the difficulty in finding satisfactory positions for these firing tracks. The time required for the laying of such a track averages from two to three days. The position must be rather well prepared and the track, composed of heavy rails and ties, must be laid on a heavy bed of good ballast. It is necessary to level and tamp the track perfectly. It is well nigh impossible to conceal a curved firing track from the air photographers and the only recourse that the French had was to construct so many curved firing tracks over the front that whenever they desired to commence an action the firing tracks were already in place and the air photographs taken by the enemy did not show any new tracks. It is not impossible to conceal a mount on the track.

146. Merits.—The merits of this mount are its sturdiness, its small maintenance and the speed with which it can be placed on a firing position and removed.

147. Demerits.—The demerit is that it requires a firing track which can not be laid under two days and which can not be concealed from the air photographer. As noted before, it is frequently difficult likewise, to find suitable positions for these firing tracks and under such circumstances an unusual amount of time may be required for its installation. It can not be laid on filled ground and, of course, time is ordinarily not available for excavating a cut if this should seem necessary in a desirable position. From the standpoint of its use at the present time a very serious demerit is that it is exceedingly difficult to use it against a moving target. It probably can be operated on a turntable of exceedingly heavy construction. In this case the sighting apparatus will have to be constructed as a part of the turntable, since the mount must be trained in azimuth until the instant of firing. It will not be impossible to construct a turntable of such strength to permit the mount to slide on it in firing. No trials have ever been made to determine whether the mount is sturdy enough to take the shock of recoil in the event that it is held rigidly to a foundation.

PLATE 108


305 MM. RAILWAY MOUNT-MODEL 1919
TOTAL WEIGHT APPROX. 403,440 LBS.
LOADS AT RAIL
33,073#
34,167#
16'-2 7/8"
56'-9 3/32"
89'-2 27/32"

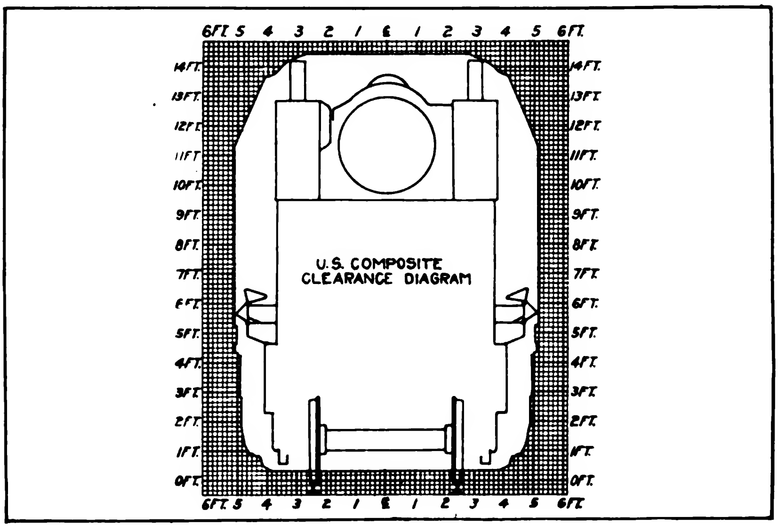

U.S. COMPOSITE
CLEARANCE DIAGRAM
6FT. 5 4 3 2 1 ℄ 1 2 3 4 5 6FT.
14FT.
13FT.
12FT.
11FT.
10FT.
9FT.
8FT.
7FT.
6FT.
5FT.
4FT.
3FT.
2FT.
1FT.
0FT.

PLATE 109

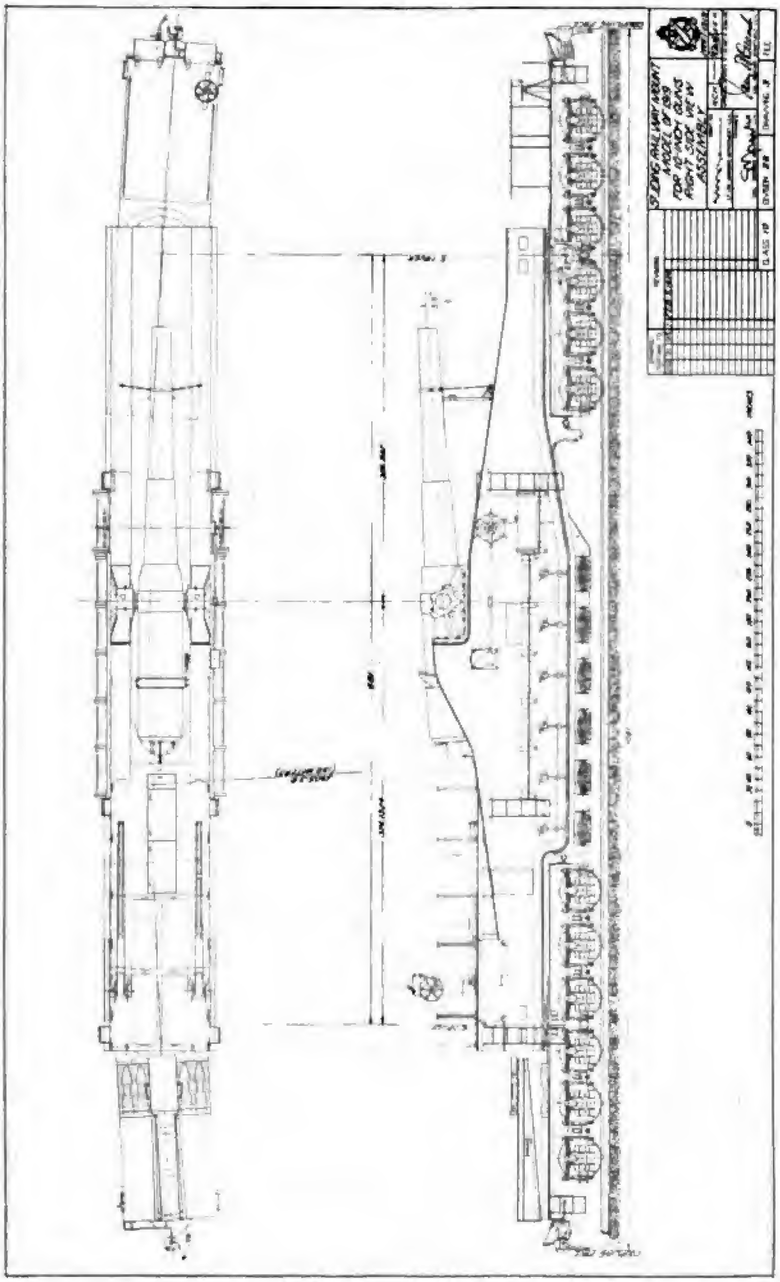


PLATE 110

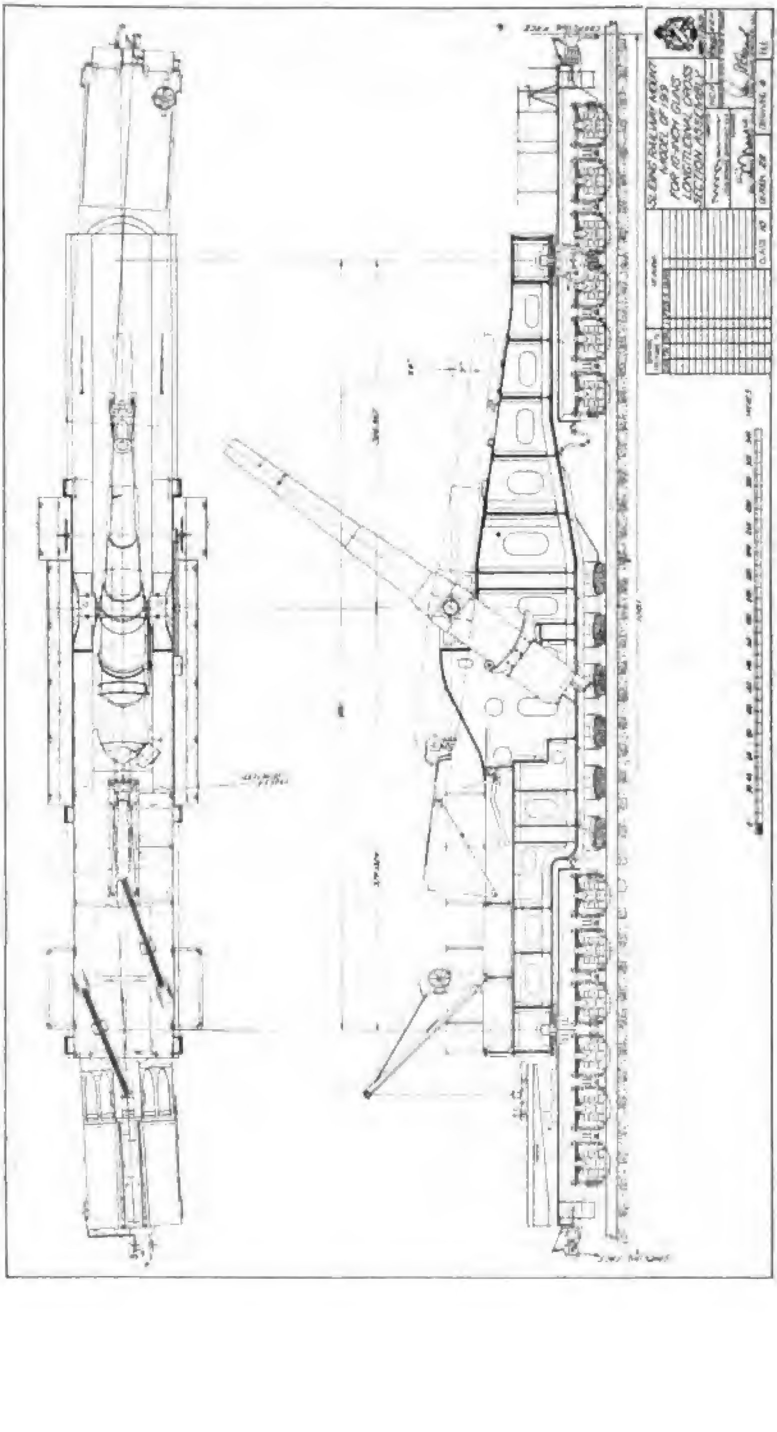


PLATE 111

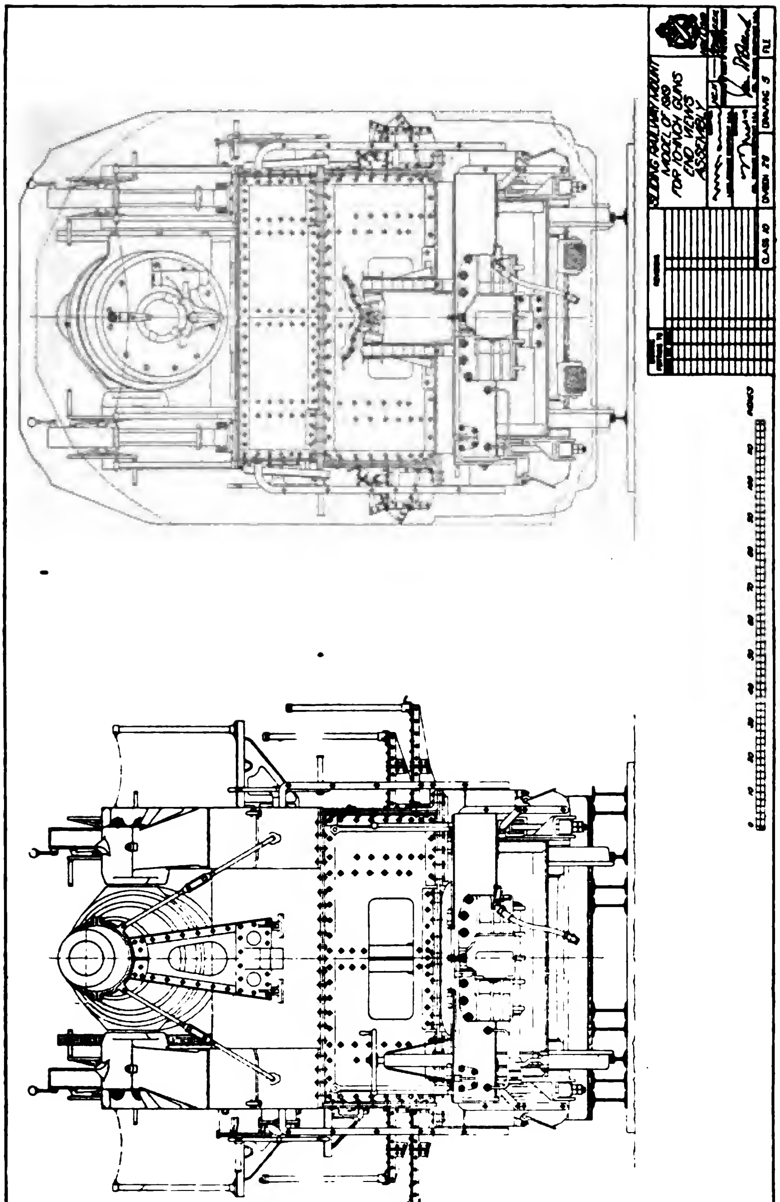

MODEL OF 1919
FOR 10 INCH GUNS
END VIEWS
ASSEMBLY
CLASS 10
DIVISION 28
DRAWING 5
FILE

PLATE 112

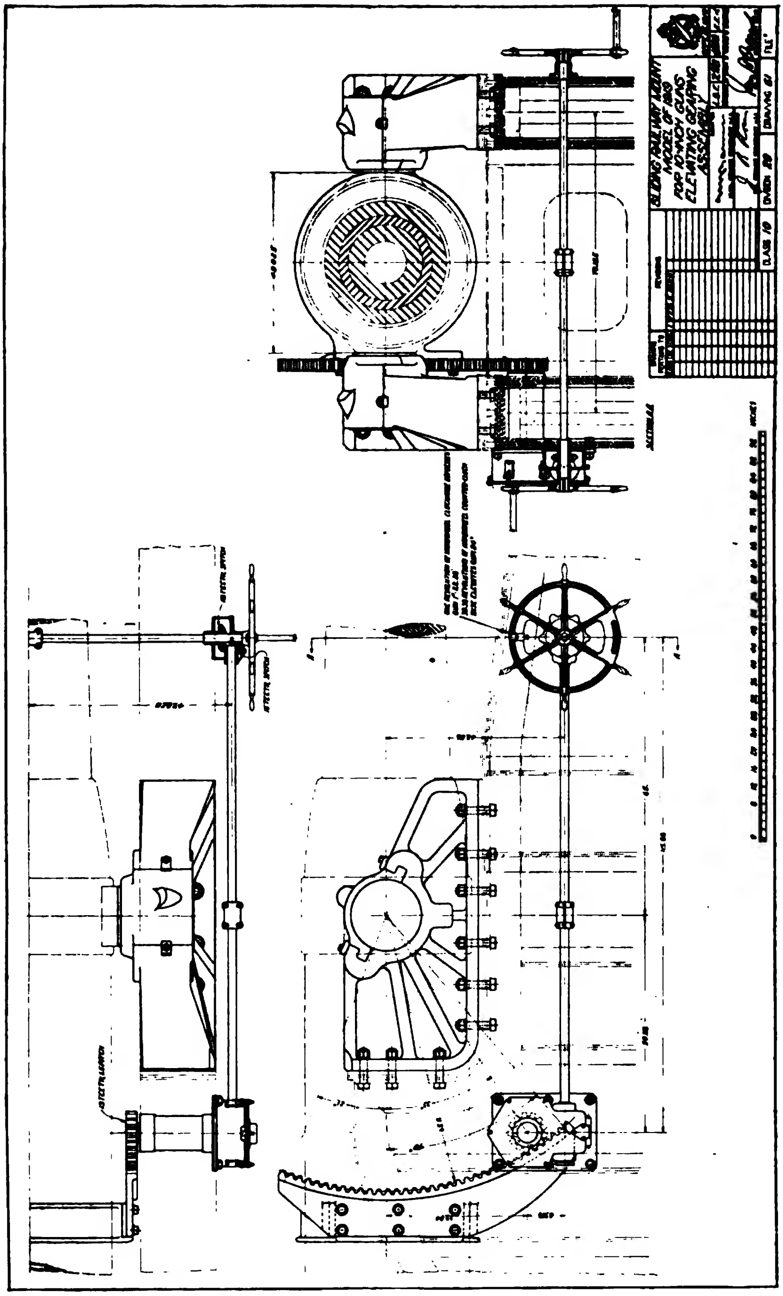

SLIDING RAILWAY MOUNT
MODEL OF 1919
FOR 10-INCH GUNS
ELEVATING GEARING
ASSEMBLY
CLASS 19
DIVISION 29
DRAWING 61

PLATE 118

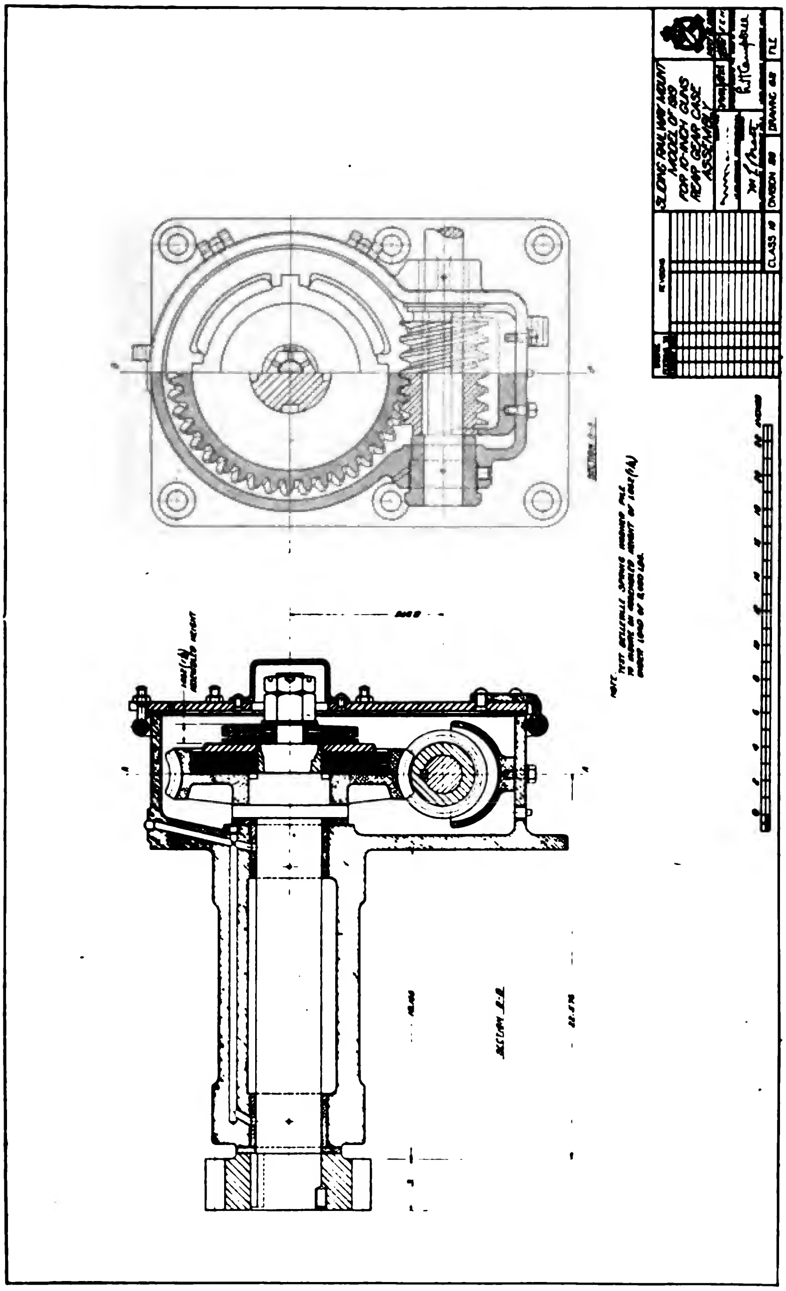

SLIDING RAILWAY MOUNT
MODEL OF 1919
FOR 10-INCH GUNS
REAR GEAR CASE
ASSEMBLY
REVISIONS
CLASS
DIVISION
DRAWING
FILE

PLATE 114

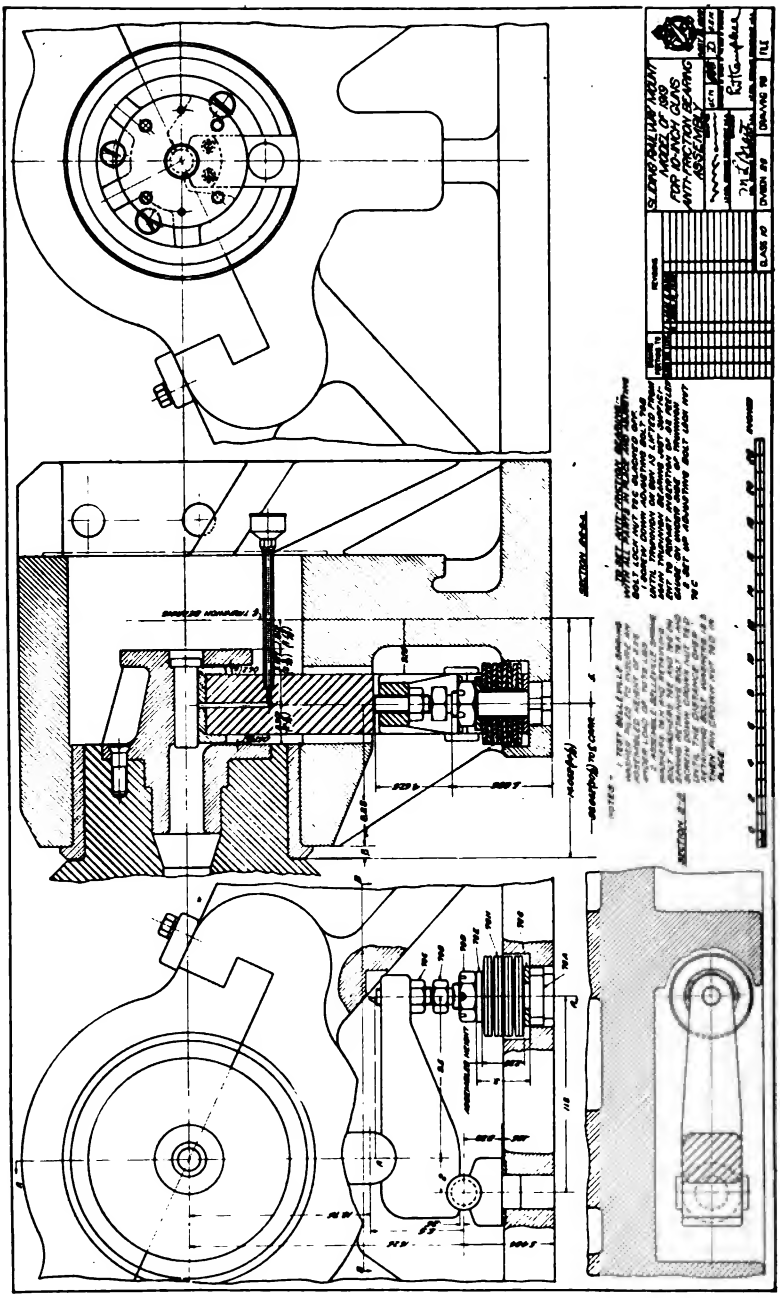

SLIDING RAILWAY MOUNT
MODEL OF 1919
FOR 10-INCH GUNS
ANTI-FRICTION BEARING
ASSEMBLY
CLASS 10
DIVISION 29
DRAWING 78
FILE

PLATE 115

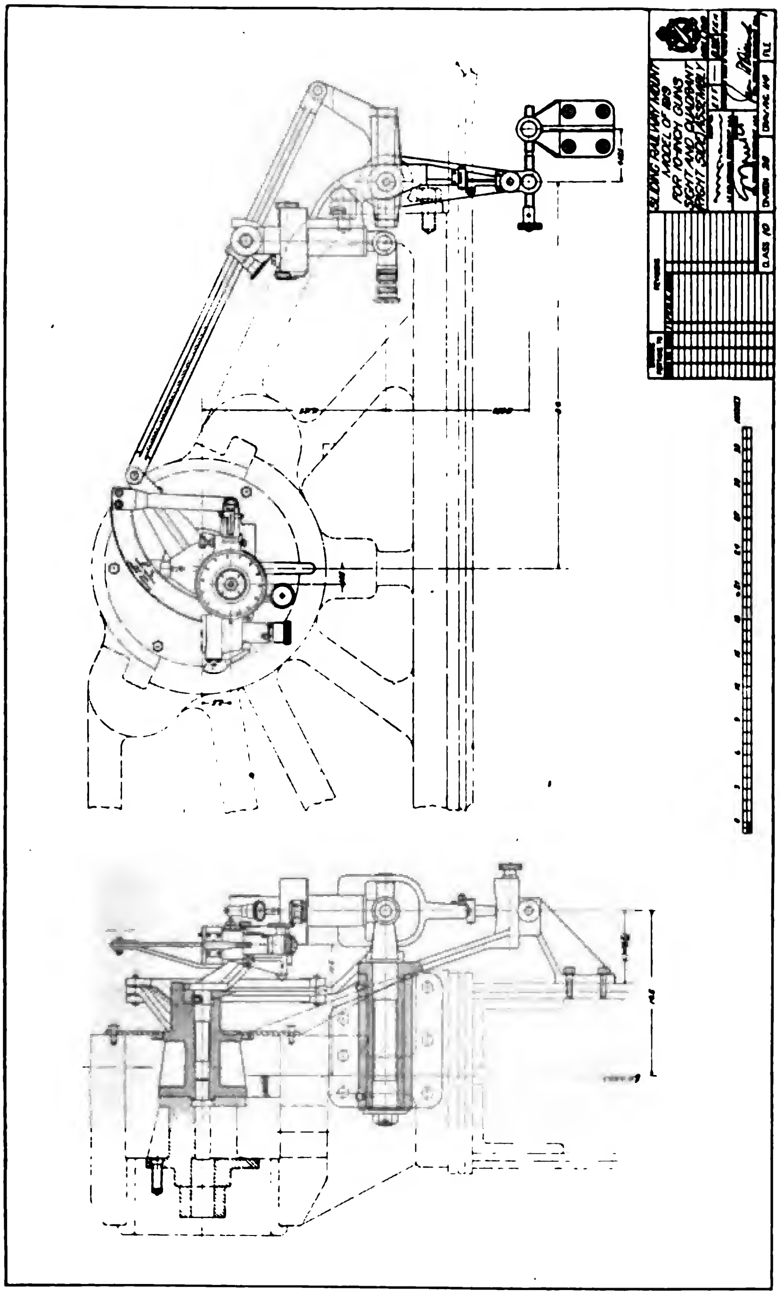

SLIDING RAILWAY MOUNT
MODEL OF 1918
FOR 10-INCH GUNS
SIGHT AND QUADRANT
RIGHT SIDE ASSEMBLY

PLATE 116

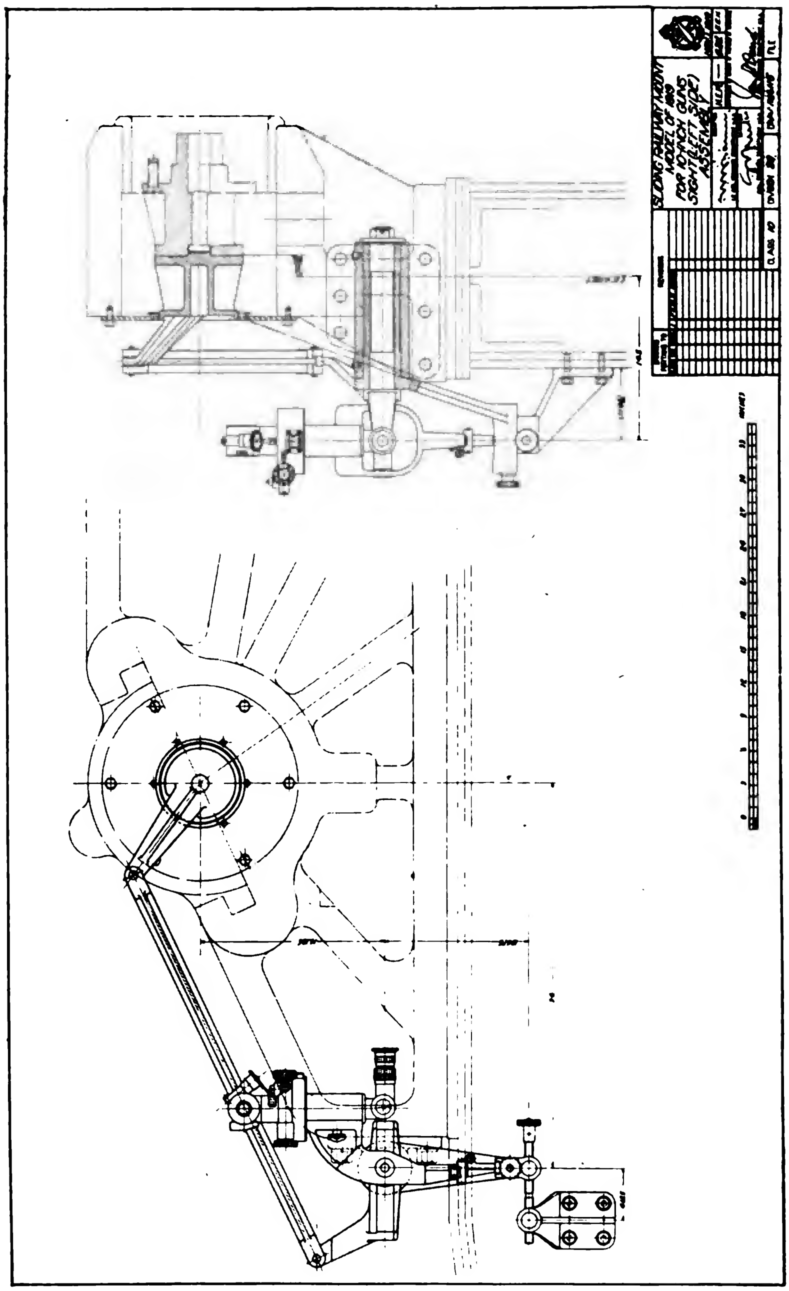

SLIDING RAILWAY MOUNT
MODEL OF 1919
FOR 10-INCH GUNS
SIGHT (LEFT SIDE)
ASSEMBLY

PLATE 117

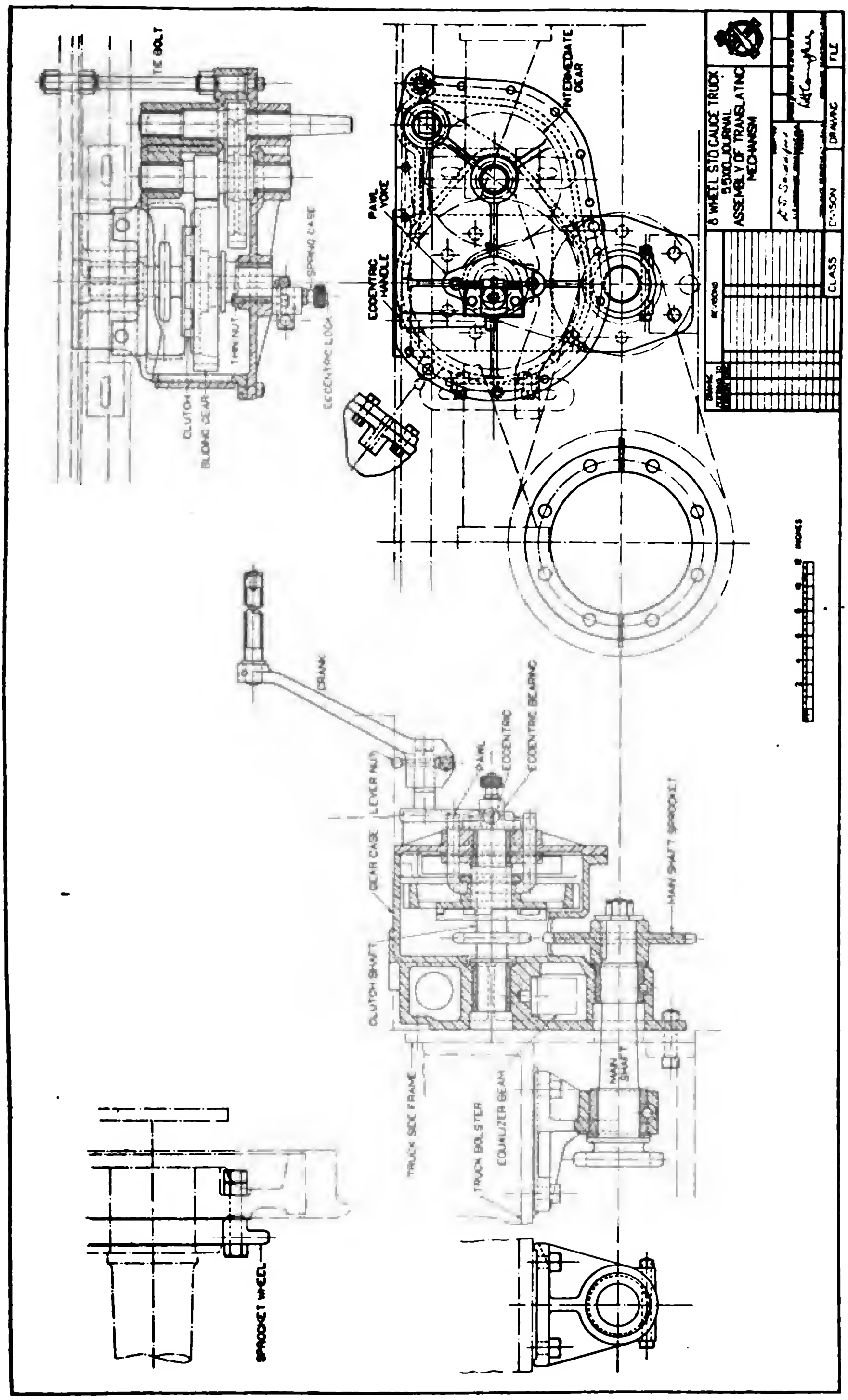

TIE BOLT
SPRING CASE
ECCENTRIC LOCK
THIN NUT
CLUTCH
SLIDING GEAR
INTERMEDIATE GEAR
PAWL YOKE
ECCENTRIC HANDLE
8 WHEEL STD GAUGE TRUCK
5.5X10 JOURNAL
ASSEMBLY OF TRANSLATING MECHANISM
CLASS
DRAWING
FILE
INCHES
CRANK
LEVER NUT
PAWL
ECCENTRIC
ECCENTRIC BEARING
GEAR CASE
CLUTCH SHAFT
MAIN SHAFT SPROCKET
MAIN SHAFT
TRUCK SIDE FRAME
TRUCK BOLSTER
EQUALIZER BEAM
SPROCKET WHEEL

PLATE 118

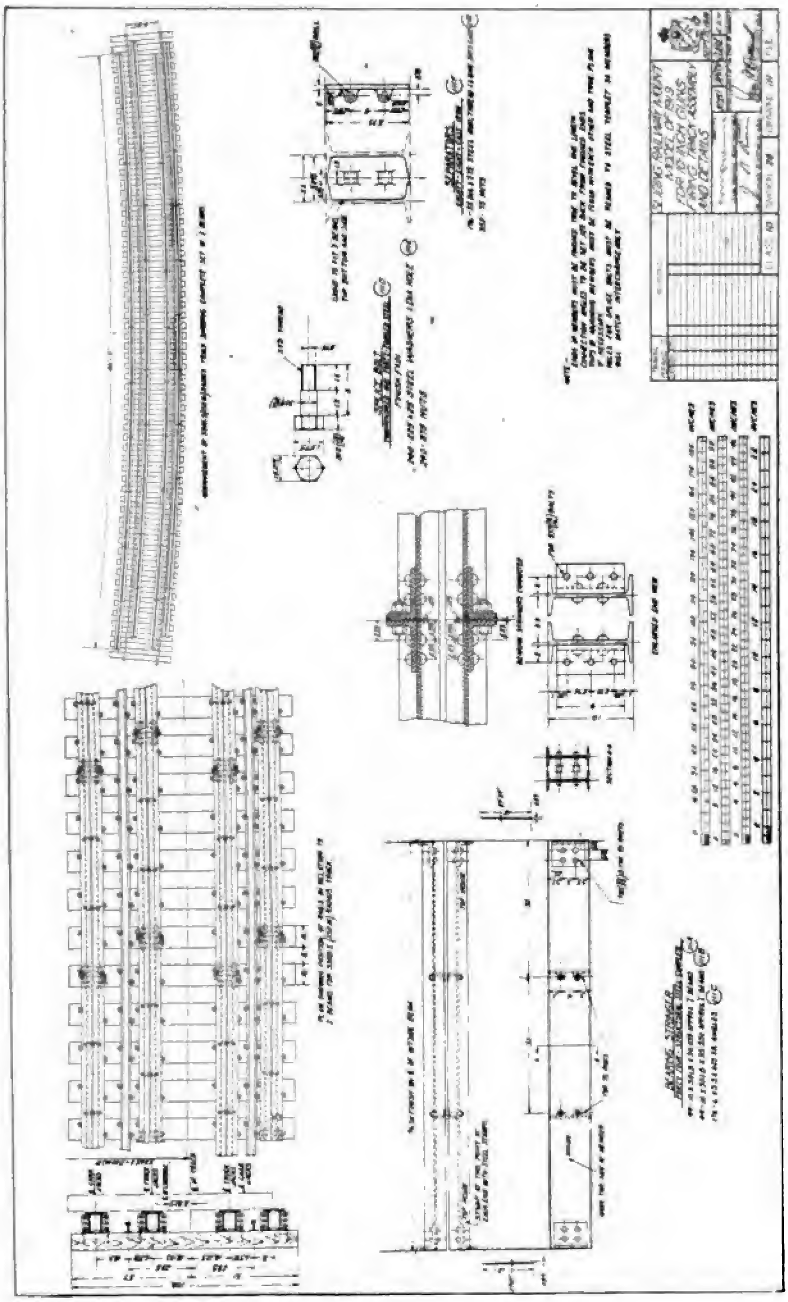


PLATE 119

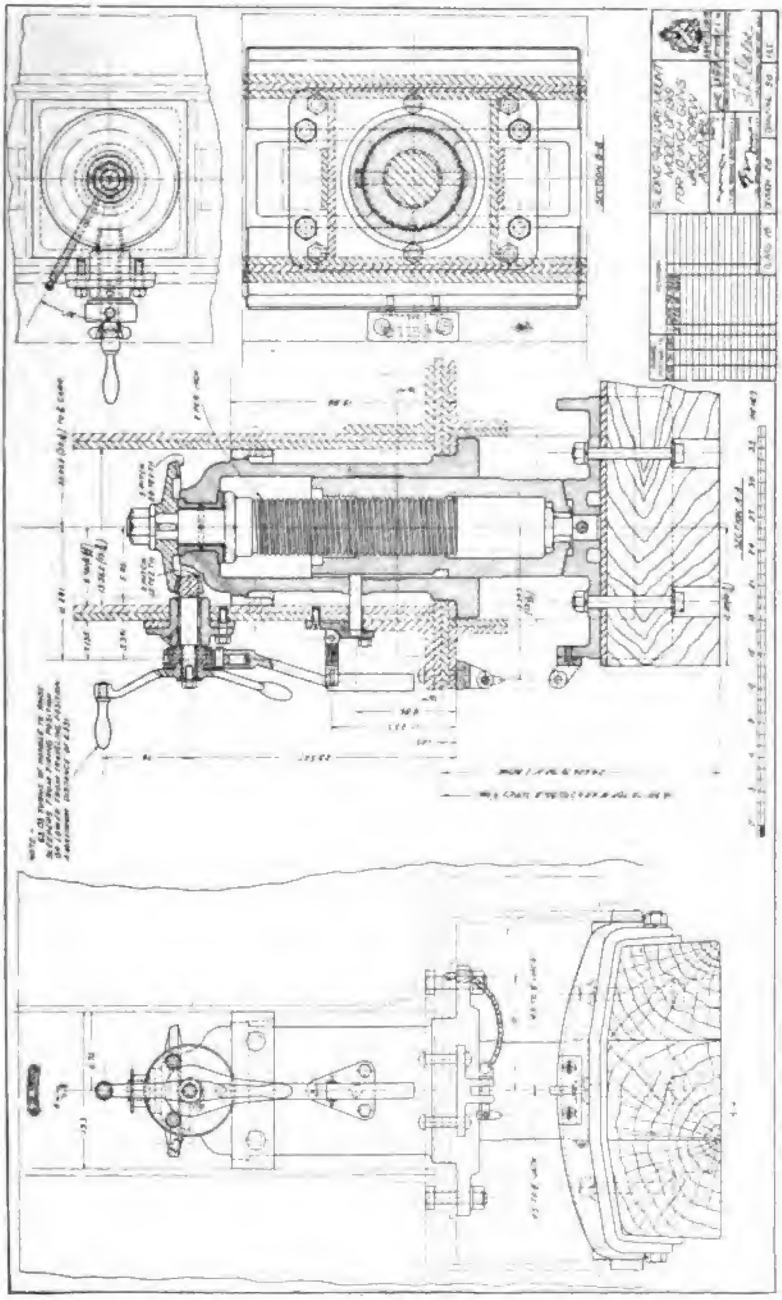


PLATE 120

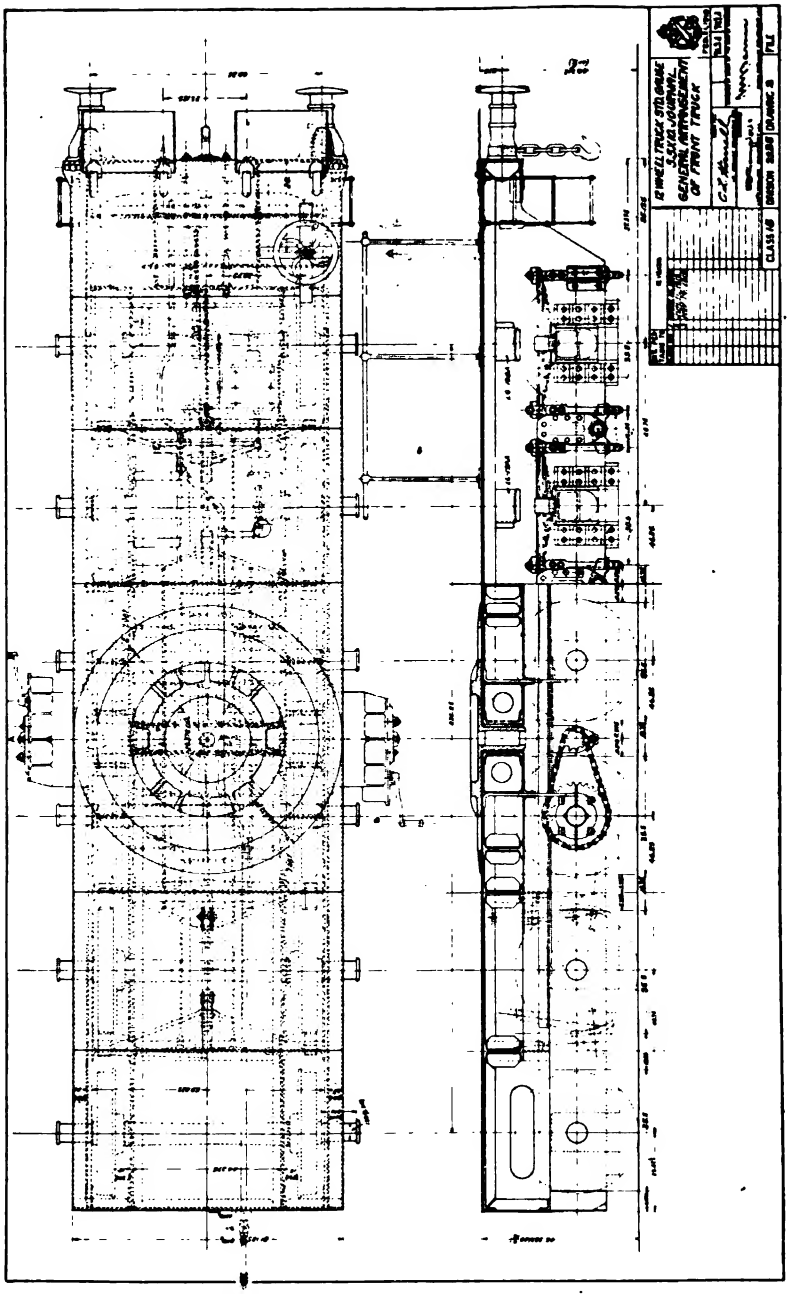


Plate 121

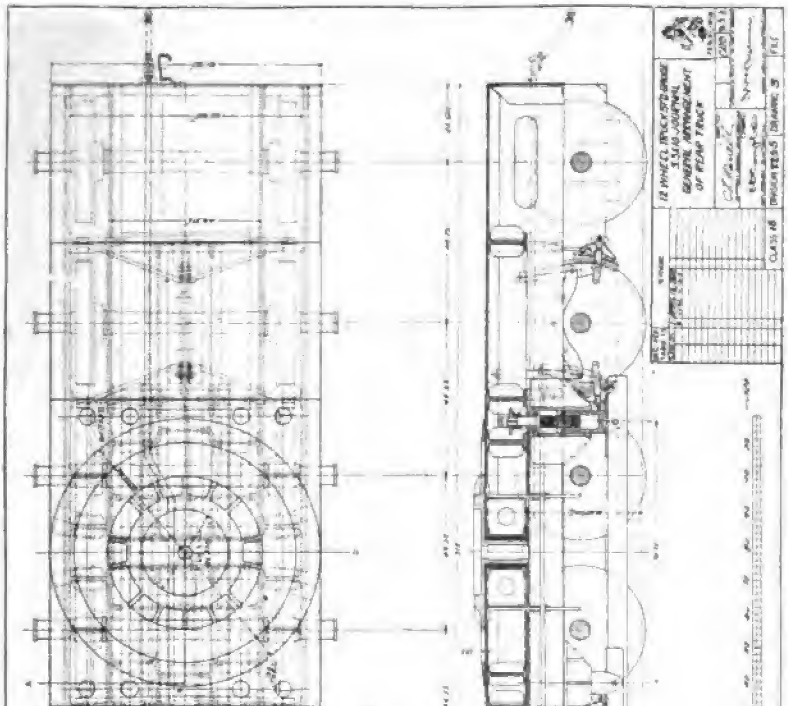


Plate 122

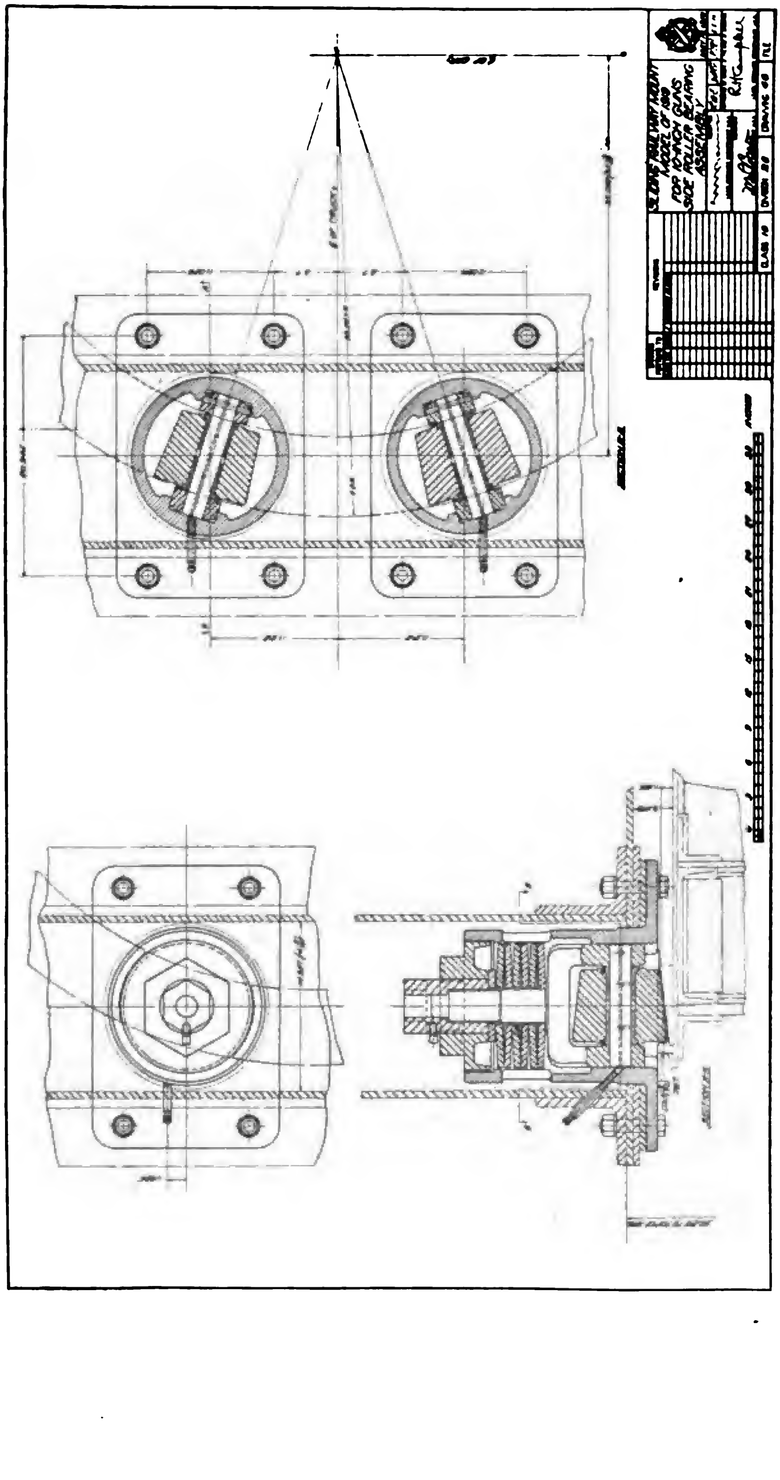


PLATE 128

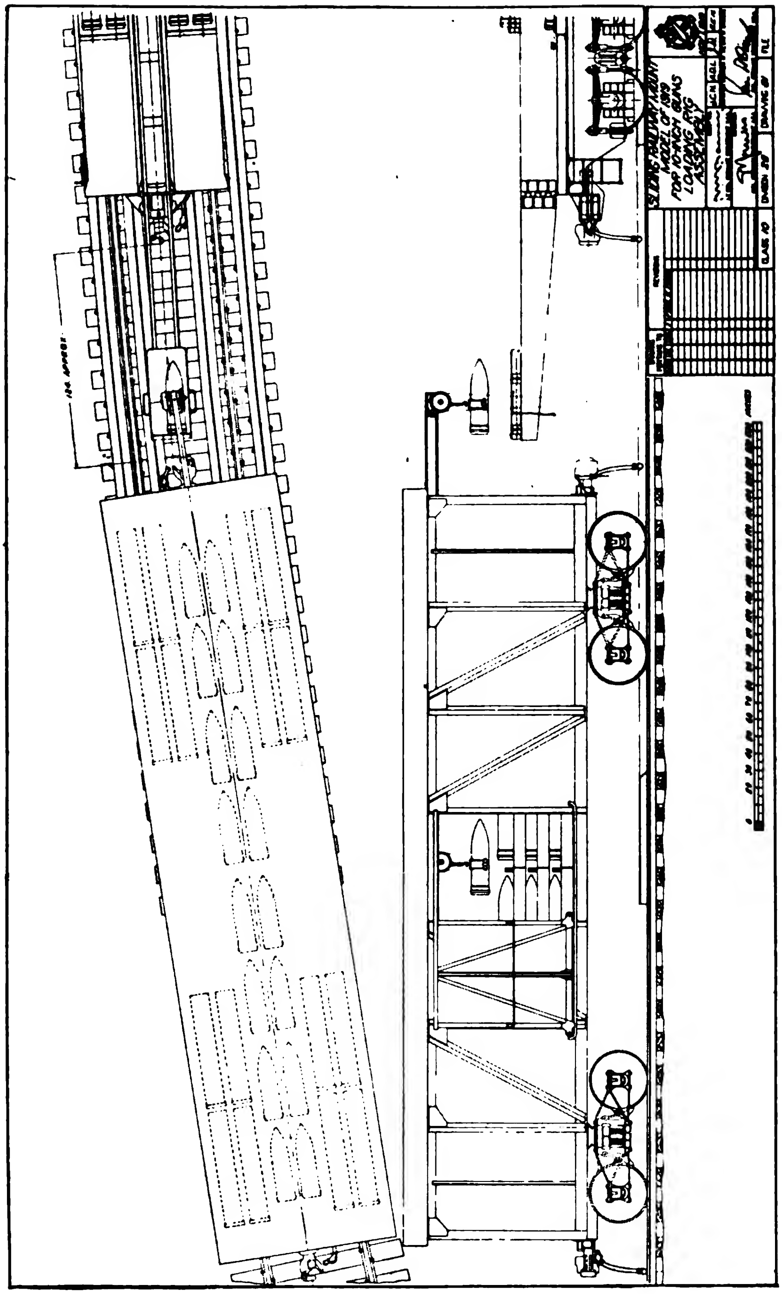

SLIDING RAILWAY MOUNT
MODEL OF 1919
FOR 10-INCH GUNS
LOADING RIG
ASSEMBLY
CLASS 10
DRAWN BY
DRAWING 69
FILE

PLATE 124

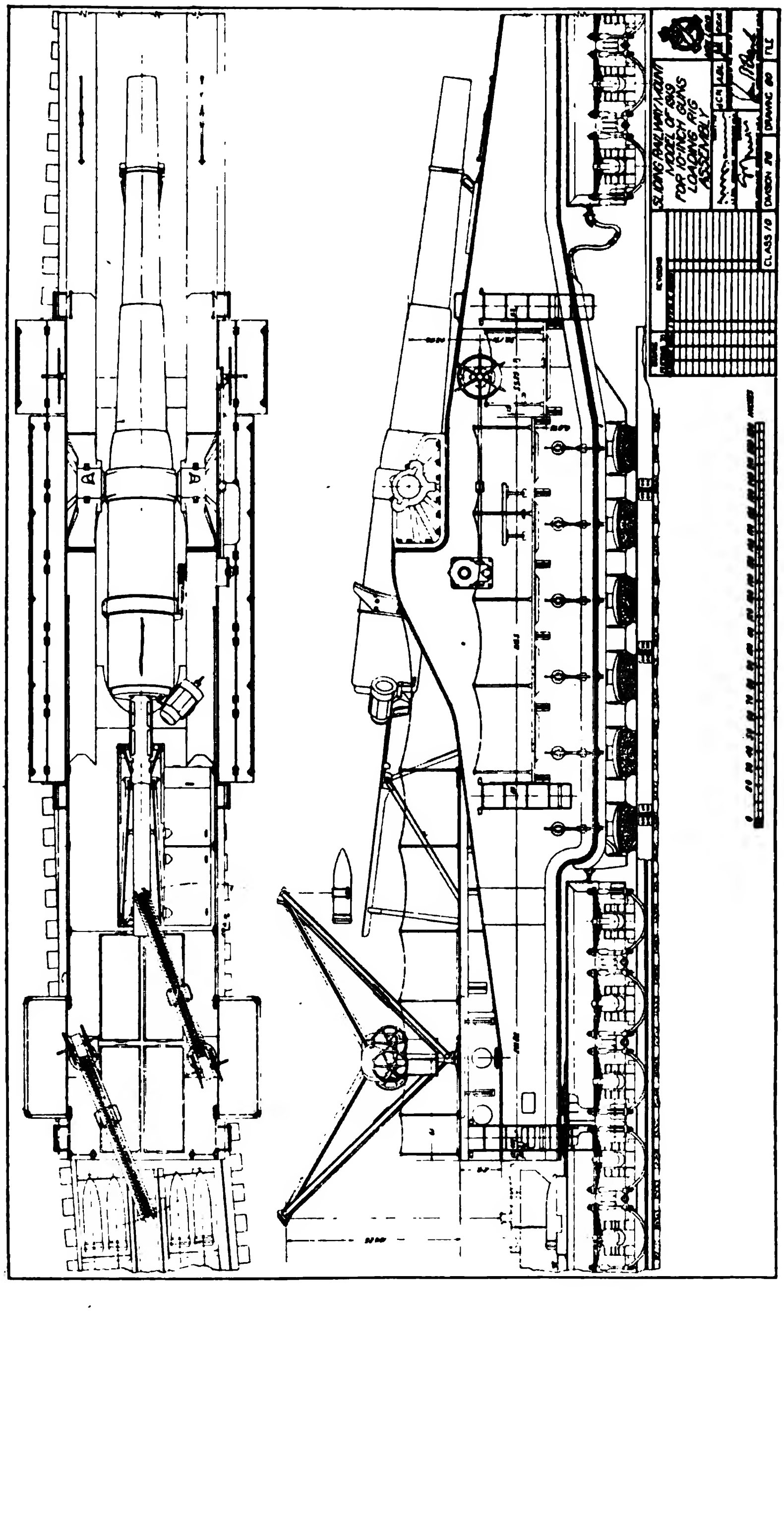

RAILWAY MOUNT
MODEL OF
FOR 10-INCH GUNS
LOADING RIG
ASSEMBLY
CLASS 10
FILE

PLATE 125

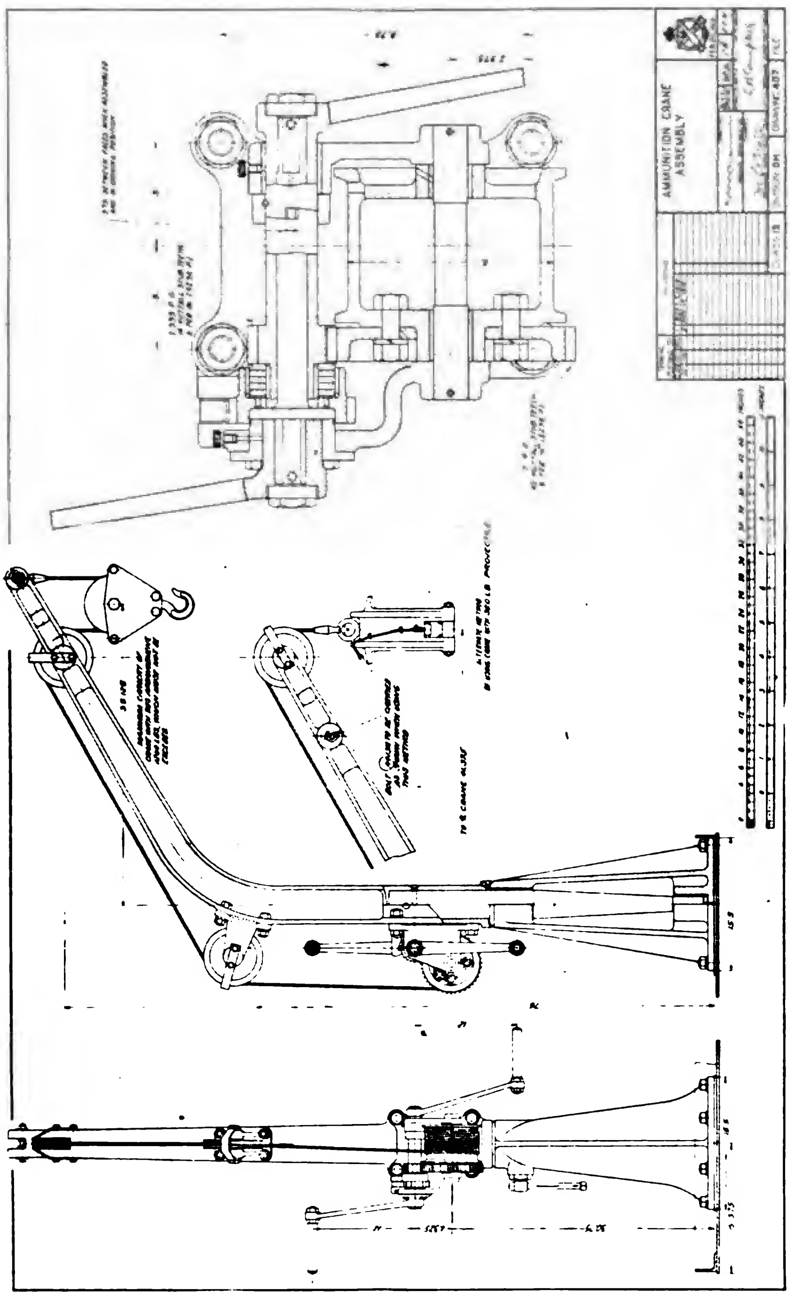


Plate 126

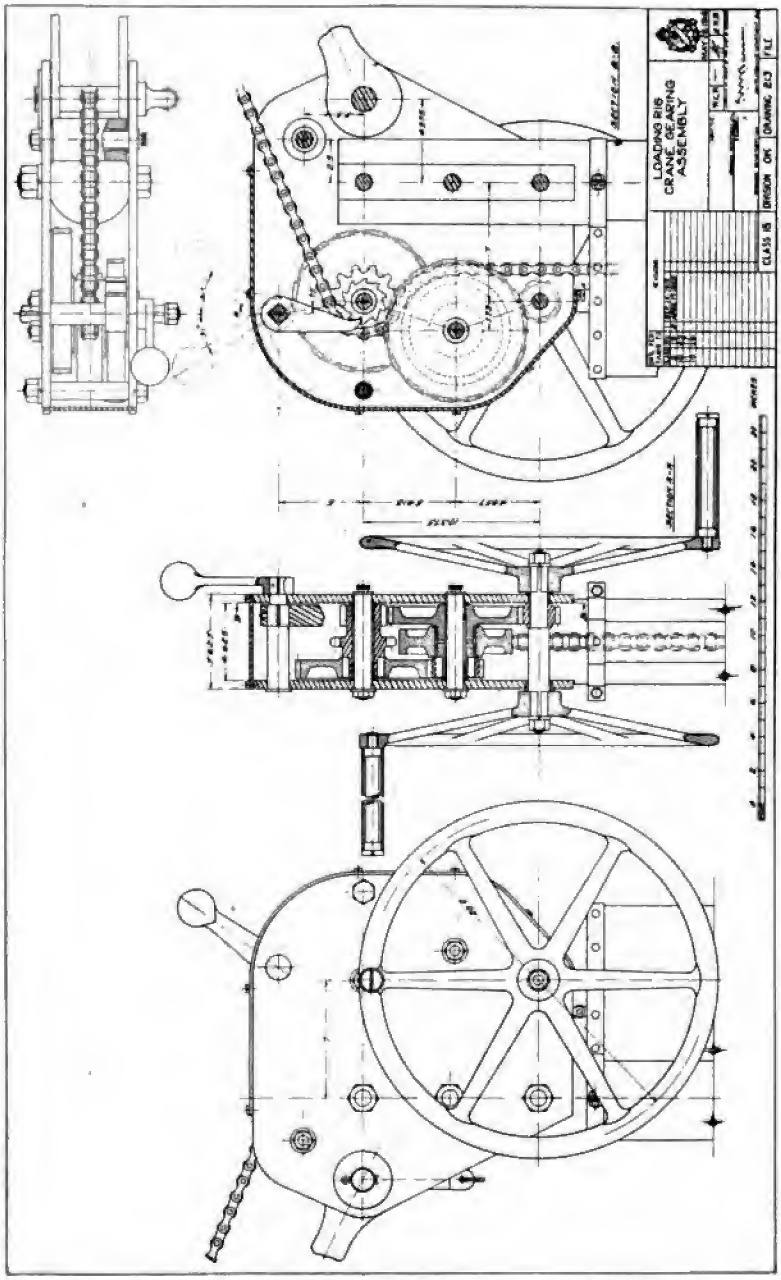


PLATE 127

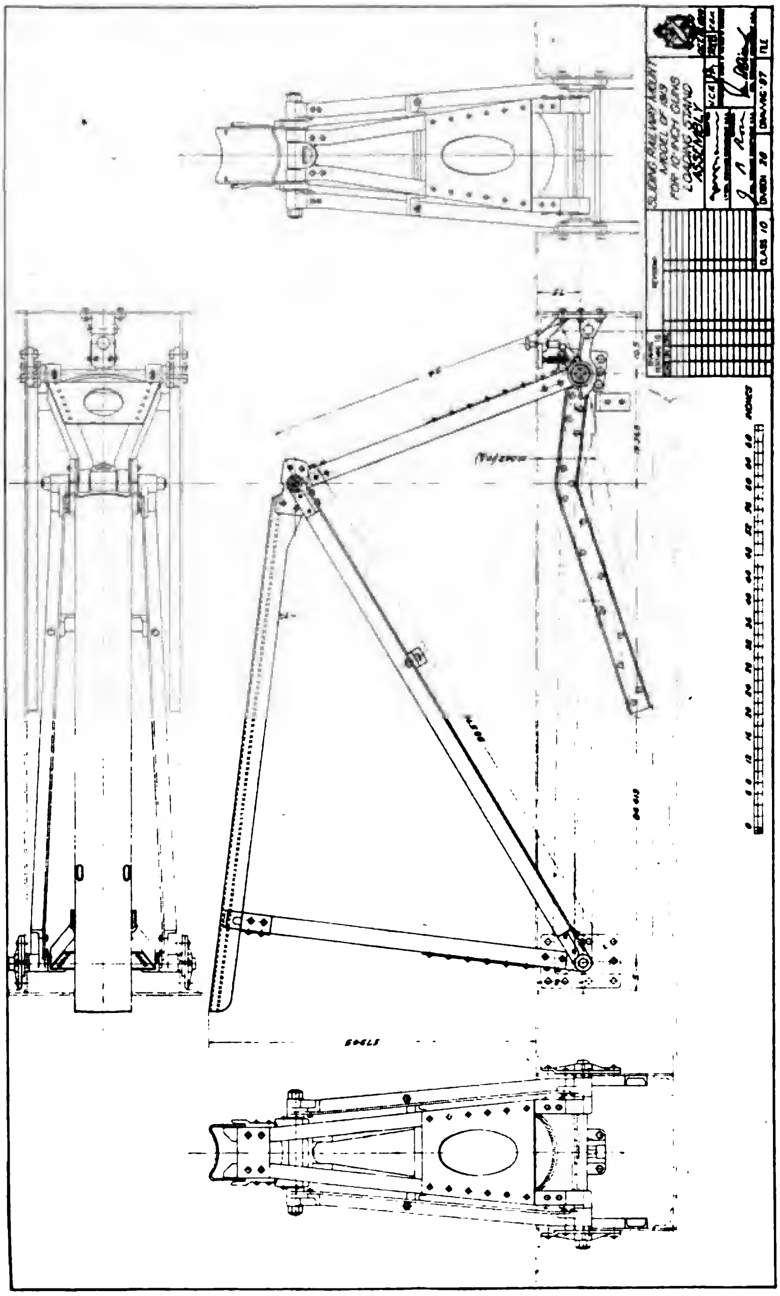
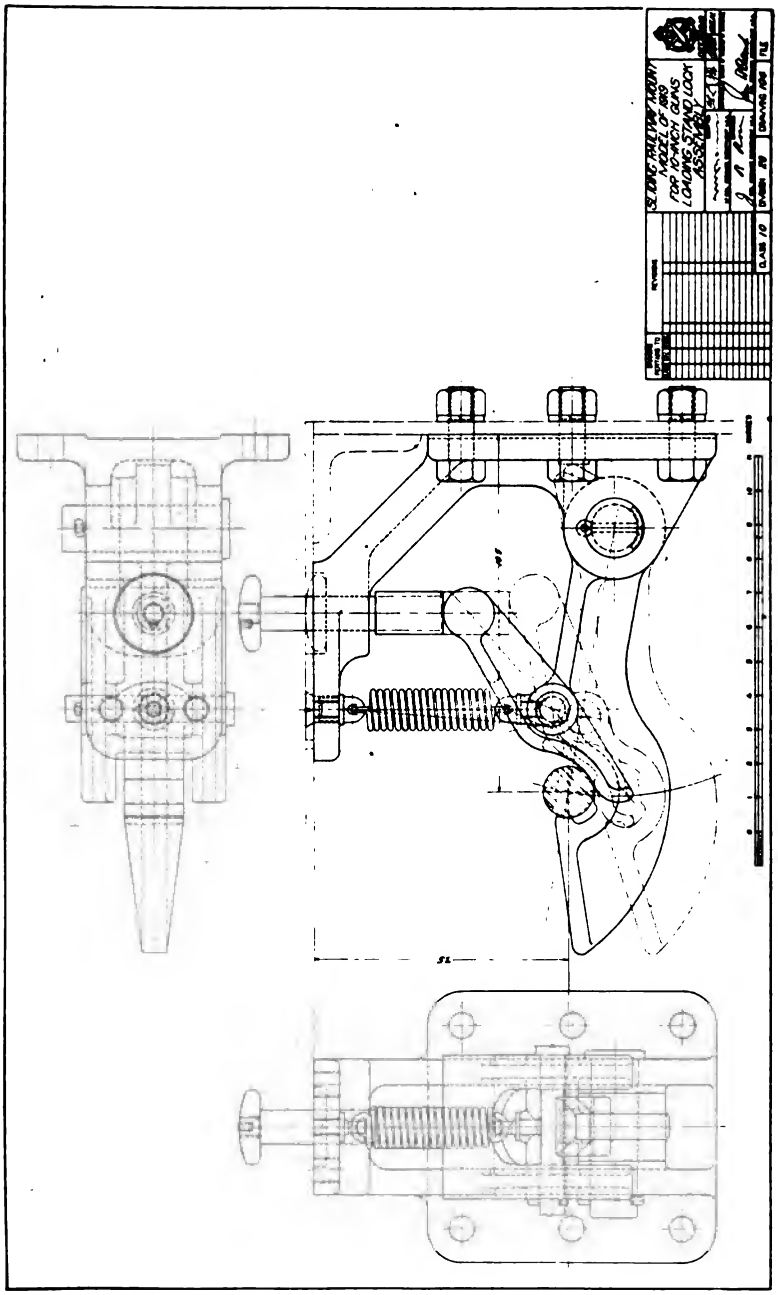

SLIDING RAILWAY MOUNT
MODEL OF 1919
FOR 10 INCH GUNS
LOADING STAND
ASSEMBLY
CLASS 10
DIVISION 20
DRAWING 97

PLATE 128


SLIDING RAILWAY MOUNT
MODEL OF 1919
FOR 10-INCH GUNS
LOADING STAND LOCK
ASSEMBLY

5.—AMERICAN 12-INCH MORTAR ON RAILWAY MOUNT.(18)

148. This mount is of the cradle recoil top carriage traverse type and is similar in design to the mount for the 8-inch gun. The recoil mechanism is hydropneumatic while that of the 8-inch mount is hydrospring. It is illustrated on plates 130 to 138.

149. GUN.—The piece used with this mount is the 12-inch coast-defense mortar, model 1890, Mark I, of 10-caliber length. It is provided with an interrupted thread breechblock which is fitted with a mechanical firing mechanism. There are 72 grooves, and the twist of the rifling is to the right, the pitch progressing from one turn in 40 calibers to one turn in 20 calibers.

150. RECOIL MECHANISM.—The recoil mechanism is of the hydropneumatic type. Two hydraulic cylinders are mounted on the bottom of the cradle and one pneumatic recuperator cylinder on the top. There is nothing unusual in the design of the hydraulic recoil cylinders. This is the first mount described on which a pneumatic recuperator is used, and it will perhaps be well to describe the recuperator mechanism in detail. It is shown in section on plate 38, and is in general typical of the design of the pneumatic recuperator used on the 12-inch Batignolles mount and the 12-inch 20-caliber howitzer. This recuperator is composed of three main parts, a cylinder which is attached to the cradle, and whose rear end, plate 38, serves as an air reservoir, a hollow piston attached to the gun, and a floating piston, the rod of which can be seen passing through the hollow piston, and the head of which fits in the air cylinder.

151. On plate 134 it can be seen that the cross head on the front end of the hollow recuperator piston is attached by means of two long tension rods to the recoil lug on the rear of the gun. The space in the recuperator to the rear of the floating piston, plate 38, is filled with air at a fixed initial pressure. The floating piston is fitted with a series of U-shaped leathers, which serve in part to retain the air pressure. The space between the floating piston and the hollow piston is filled with a heavy oil or light grease. It can thus be seen that if there is any leakage in this cylinder it is a leakage of the oil which fills the space between the floating and hollow piston, since the air can not escape except by passing both the floating piston and the oil piston. When the gun recoils, the tension rods shown on plate 134 pull the hollow piston back, and the pressure transmitted through the oil or grease forces the floating piston to the rear at the same time. The length of recoil is 30 inches and the position of the floating piston at maximum recoil is shown by dotted lines. As soon as the gun has ceased to recoil the air pressure behind the floating piston forces it forward and in turn pressure is

transmitted through the oil and forces the hollow piston and the gun forward.

152. The front end of the rod of the floating piston projects through the hollow piston and beyond the end of the bracket, which is attached to the gun sleigh. As oil leaks out of the hollow piston the floating piston moves forward under the air pressure. The forward end of the floating piston rod is graduated and when certain of these graduations appear it is an indication that the oil supply must be replenished. As additional oil is forced in the floating piston moves to the rear, again building up the air pressure. The oil pump used in this operation can be seen mounted on the cradle beside the recuperator cylinder. A supply of oil is carried in the pump casing and the pump is operated by means of the long lever shown in the space between the hollow and floating pistons. On plate 134 an air bottle can be seen on the working platform of the mount. This bottle is connected by a small pipe with the rear end of the recuperator cylinder and supplies it with air to increase the pressure whenever necessary.

153. The cradle is noticeably of a clumsy design. The mortars used on these mounts were originally mounted in their seacoast carriage by means of trunnions attached to the gun. To get the required amount of bearing surface for a recoil of desirable length, it was necessary to mount the gun in what is termed a sleigh. This sleigh is composed of two rings and two runners or splines, plates 38 and 134. The forward ring fits over the tapered muzzle of the gun and the rear ring over the breech. They are connected by two runners which fit over the original trunnions of the gun, thereby attaching the entire sleigh rigidly to the gun. This sleigh is in turn mounted in the cradle, which is necessarily very wide to accommodate the large sleigh runners. The cradle is supported in the side frames of the top carriage by its own trunnions.

154. Elevating Mechanism.—Elevation from minus 5 degrees to plus 65 degrees is secured through a segmental circular rack attached to the bottom of the cradle; a pinion meshing with this, a slip-friction device, wormwheel and worm, and a set of bevel gears leading to the handwheel. Any excessive thrust due to fire causes slipping in the friction device and can not impose excessive strain on the gears. One turn of the handwheel moves the mortar through 1.004 degrees in elevation. Details of this mechanism are shown on plate 38.

155. Traversing Mechanism.—The traversing mechanism provides for a total movement of 360 degrees, as with the 8-inch carriage. Gun and carriage are carried in cast steel side frames on a racer casting which is supported by conical traversing rollers, plate 135. A complete circular rack is mounted on the base ring; a pinion of

the traversing mechanism which is mounted on the racer meshes with this rack. This pinion connects through a vertical shaft, worm, and wormwheel with the operating handwheel. Any strain from the pressure of the projectile against the lands of the gun in firing is taken up as thrust on the worm. An azimuth circle with a pointer is provided for reading changes in azimuth. One turn of the handwheel moves the mortar through 0.837 degrees in azimuth.

156. GUN CARRIAGE.—The mortar carriage, plates 38 and 134, is similar in general design to the 8-inch barbette carriage, model of 1918. Certain radical differences have been made in the details, of course. In this carriage the pneumatic recuperator has been substituted for the spring recuperator used in the 8-inch gun. The elevating mechanism comprises a segmental spur-gear rack and a pinion, while the 8-inch mount was provided with a Hindley worm and segmental worm-gear rack. The base ring of the 8-inch mount was provided with a pintle at its center, while in this case the pintle is part of the racer and is of very large diameter, plate 38. On the 8-inch mount the traversing rack is attached to the base ring inside the roller track. On the 12-inch mortar mount the traversing rack is attached to the outside of the roller track. On the rear of the working platform of this mount an ammunition table is provided, since the projectiles are of such weight and size that they can not be handled by the simple method used on the 8-inch mount.

157. RAILWAY CAR BODY.—The railway car body for a number of these mortars is identical with that of the railway car model 1918, Mark I, plate 133, for the 8-inch gun. The mortar carriage proved sufficiently heavy to cause a deflection of about an inch in the center of the 8-inch design of car body, hence a modified design was made in which the depth of the web plates was increased, especially in the inclined portions of the car body. Four-fifths of the total number of mortar car bodies are of this latter design.

158. ANCHORAGE.—The scheme employed in anchoring this mount is shown on plates 130, 131, and 136. It is identical with that used with the 8-inch mount.

159. TRUCKS.—The trucks on this car differ from those used with the 8-inch mount due to the heavier load carried. They are 6-wheel type with 5.5 by 10 inch journals and 28-inch wheels. Both hand and air brakes are provided. Details are shown on plate 137. A set of equipment for transporting the mount over narrow-gauge track is provided and is in every way similar to that furnished with the 8-inch mount, plates 99–105.

160. AMMUNITION SUPPLY SYSTEM.—The ammunition car is the same as that provided for the 8-inch mount, plate 106. It is located

directly back of the gun car in firing so that the ammunition can be let down directly on the truck mounted on the special track built on the car body. From this truck it is picked up by a jib crane on the rear of the mortar-operating platform and is swung around and lowered to a loading stand on the back of the latter. From here it is slid into the mortar along a loading tray which can be put in place temporarily between this loading stand and the mortar breech. The loading angle is minus 5 degrees. This arrangement is illustrated in detail in plate 138.

161. MAINTENANCE.—The only especially novel feature in this mount, so far as American practice is concerned, is the pneumatic recuperator. Early in proof tests the valves on the pump for recharging the recuperator stuck on one occasion. This difficulty was easily remedied and the recuperator has since operated perfectly. No further difficulty should be experienced in the maintenance of this mechanism. The mortar and carriage are somewhat heavier than the 8-inch gun and carriage and cause a very marked deflection in the 8-inch design of car body used with 17 of these mortars. There is a possibility of the development of a permanent set or sag in these.

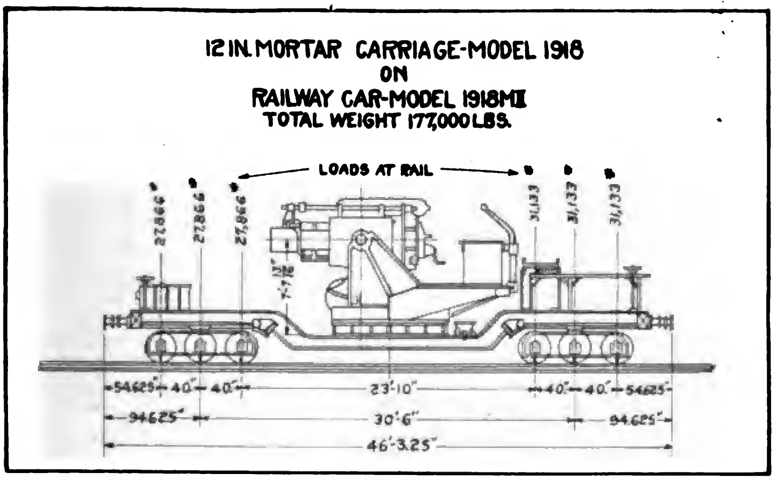
162. DIFFICULTIES INVOLVED IN SERVICE.—Proof of this mount indicates that it operates satisfactorily in every respect at elevations between 35 degrees and 65 degrees. At lower elevations some difficulty has been experienced with the settling of outrigger floats in the ground and particularly with jumping of the car. It appears that at elevations below 25 degrees the mount is dangerously unstable.

163. The heavy deflection of the 8-inch design of car body may cause considerable difficulty in emplacing, as the car must be raised by auxiliary jacks before the standard jacking beams can be inserted. This operates merely to increase the time required for emplacing and removing the mounts and it should not constitute a serious difficulty.

164. MERITS.—One of the merits of this carriage is its system of anchorage, which is identical with that of the 8-inch railway carriage. Attention should also be called to the cradle, which is of excellent design; it is felt that it will give excellent service.

165. DEMERITS.—Some difficulty may be experienced in using a few of these mounts in the field, inasmuch as the deflection of the underframe is so great as to make it impossible to use the jacks provided for lifting the car in order that the firing beams and sleepers may be placed to form the firing platform. It may be necessary to use auxiliary jacks.

PLATE 129


12 IN. MORTAR CARRIAGE-MODEL 1918
ON
RAILWAY CAR-MODEL 1918MII
TOTAL WEIGHT 177,000 LBS.
LOADS AT RAIL
27,866#
27,866#
27,866#
31,133#
31,133#
31,133#
54.625"
40"
40"
23'-10"
40"
40"
54.625"
94.625"
30'-6"
94.625"
46'-3.25"

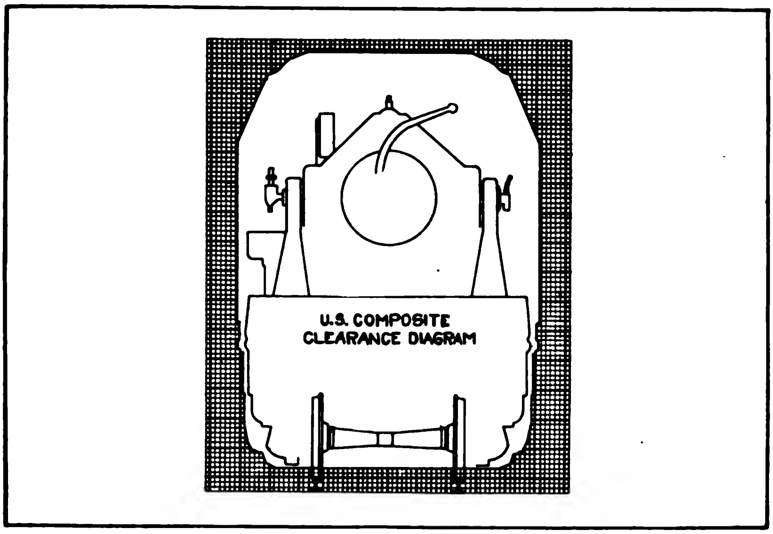
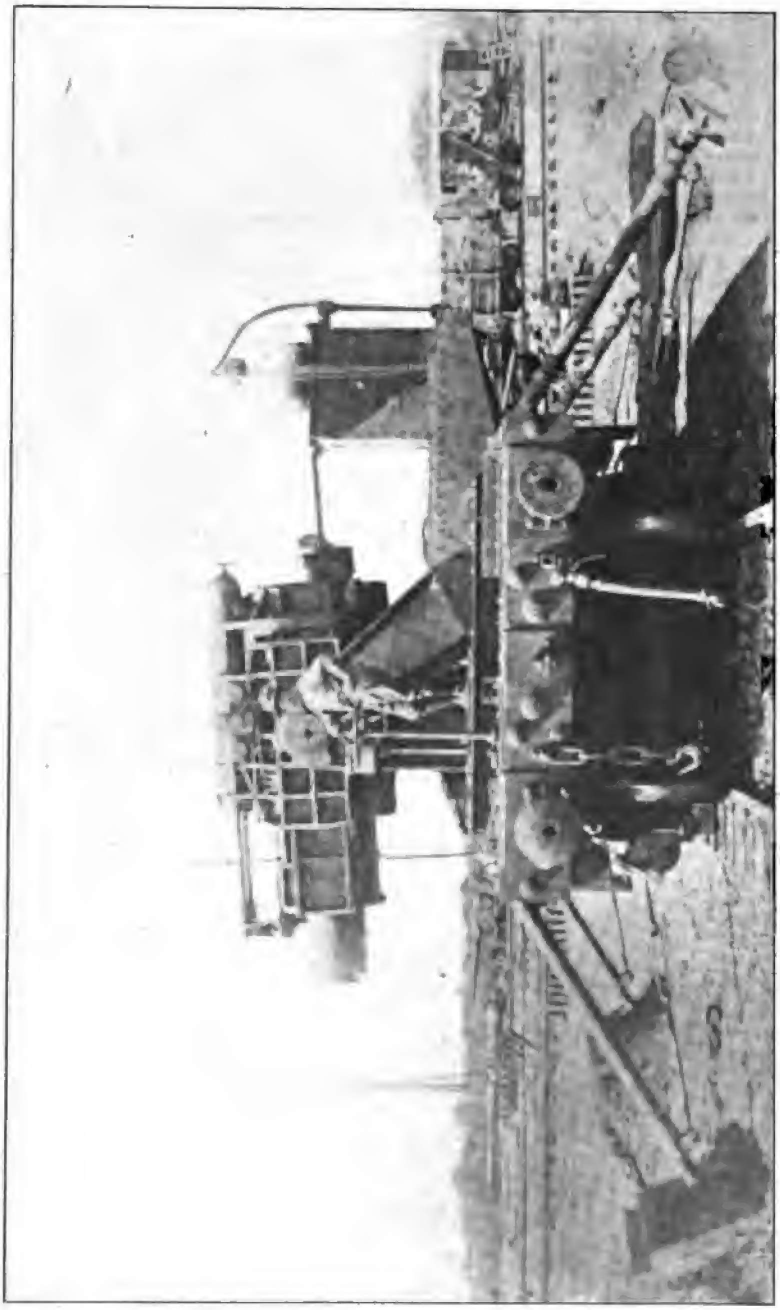

U.S. COMPOSITE
CLEARANCE DIAGRAM

PLATE 130



12-INCH AMERICAN MORTAR ON RAILWAY MOUNT.

PLATE 131

12-INCH AMERICAN MORTAR ON RAILWAY MOUNT.

PLATE 130

12-INCH AMERICAN MORTAR ON RAILWAY MOUNT.

12-INCH AMERICAN MORTAR ON RAILWAY MOUNT.

PLATE 134

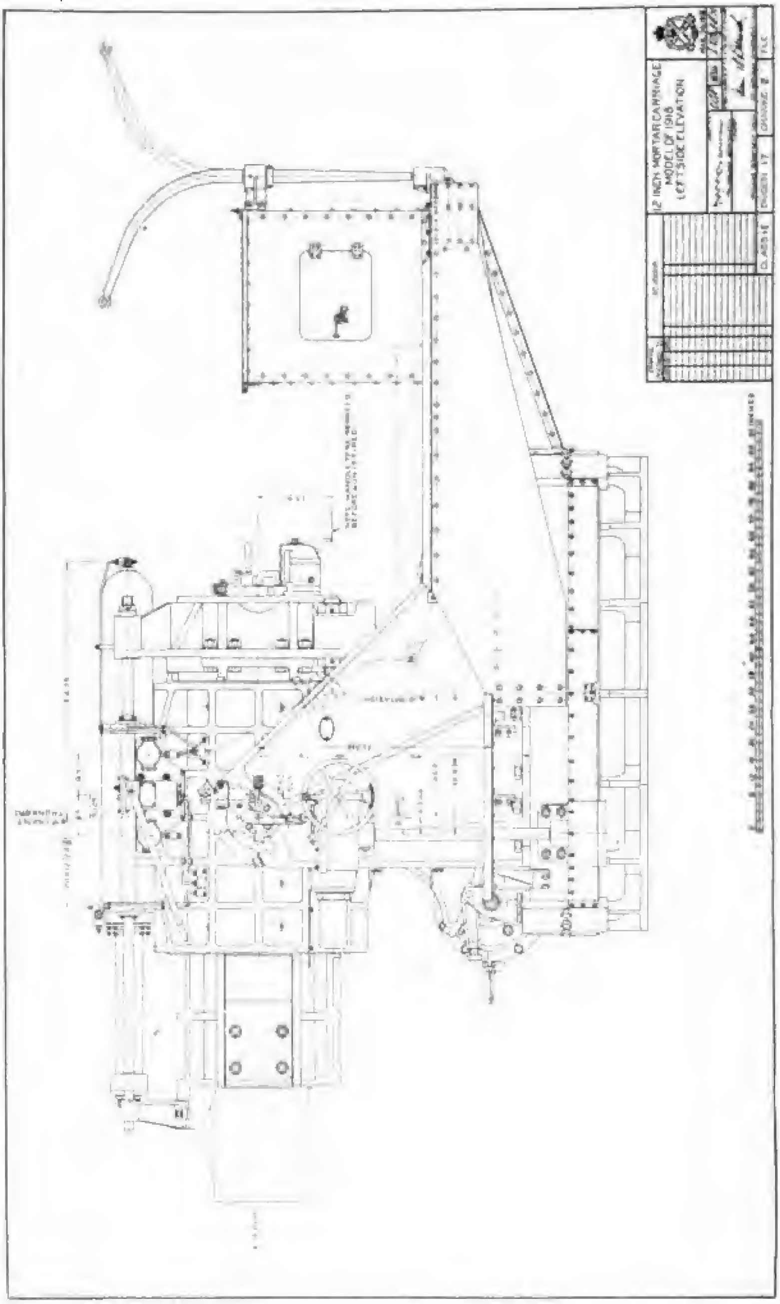


PLATE 135

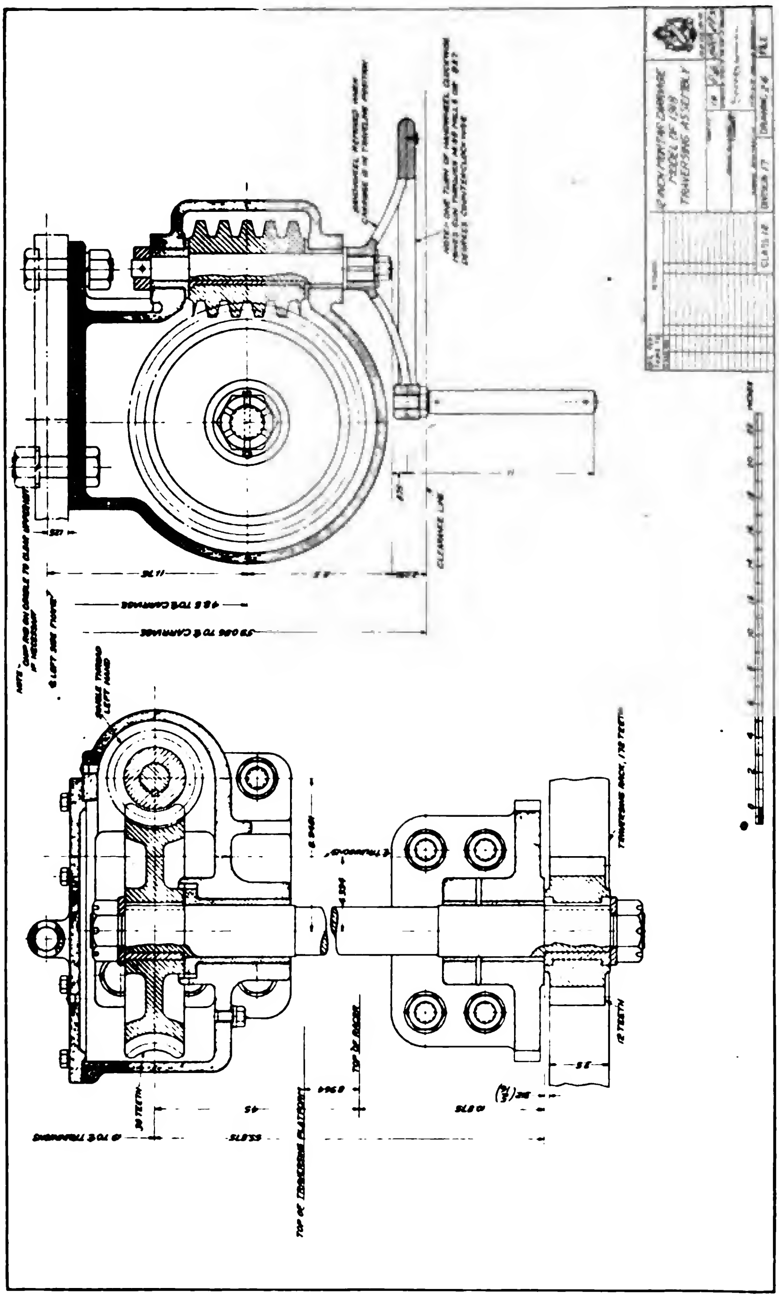


PLATE 136

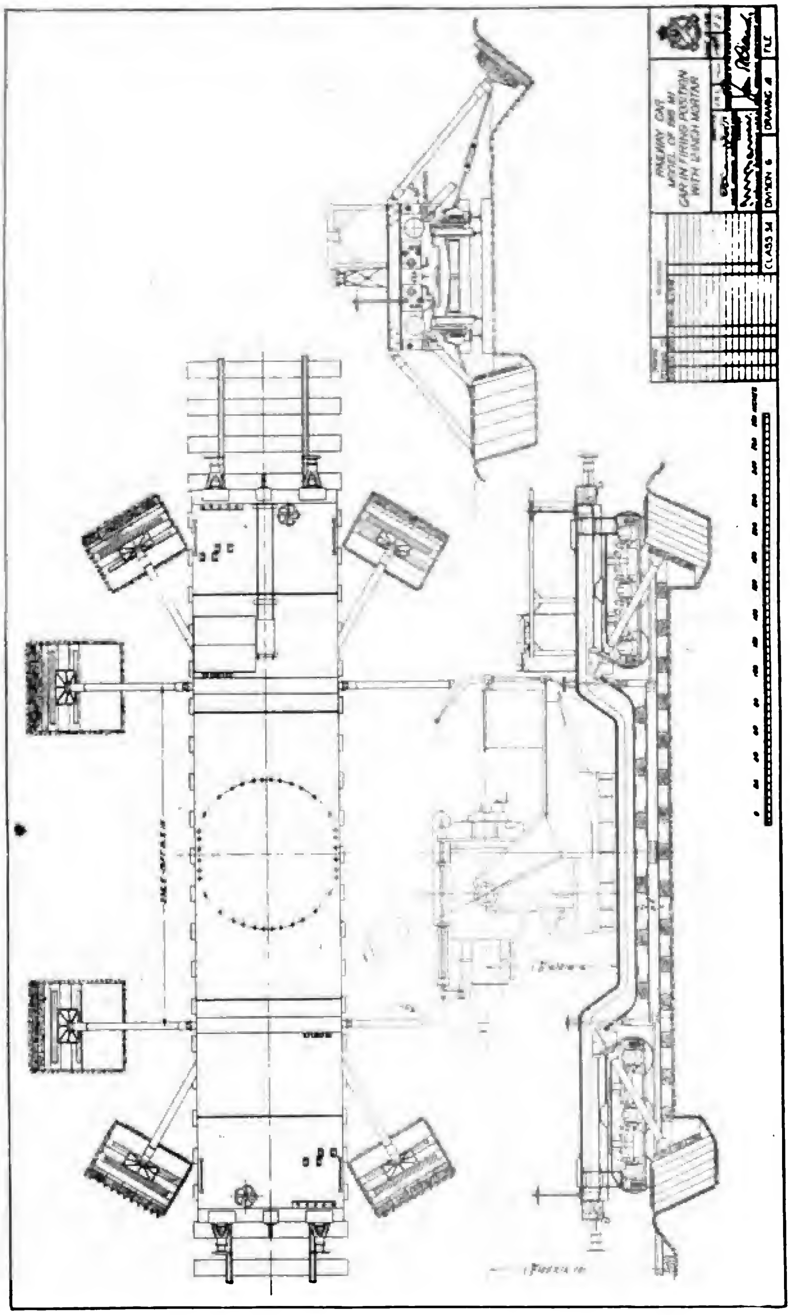


PLATE 137

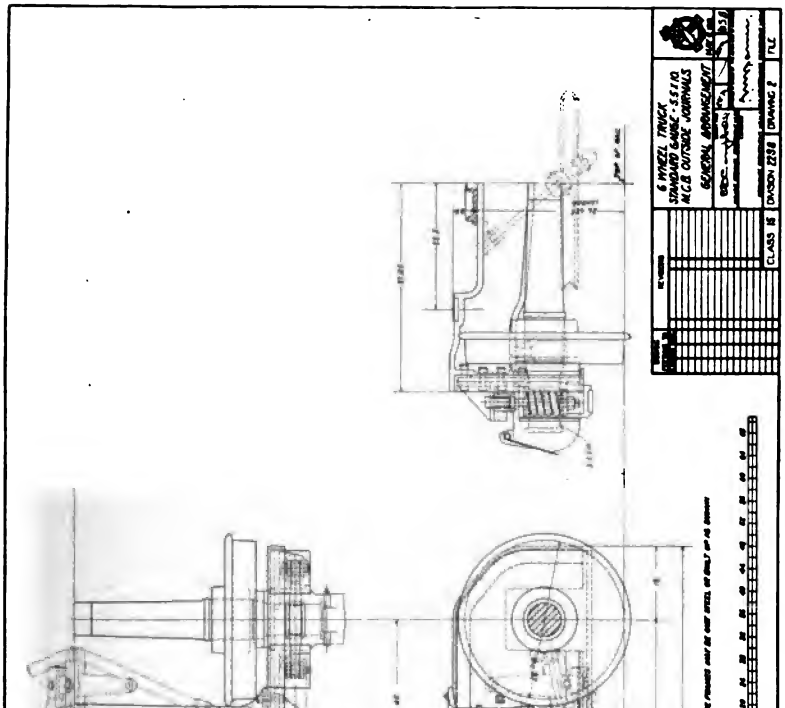
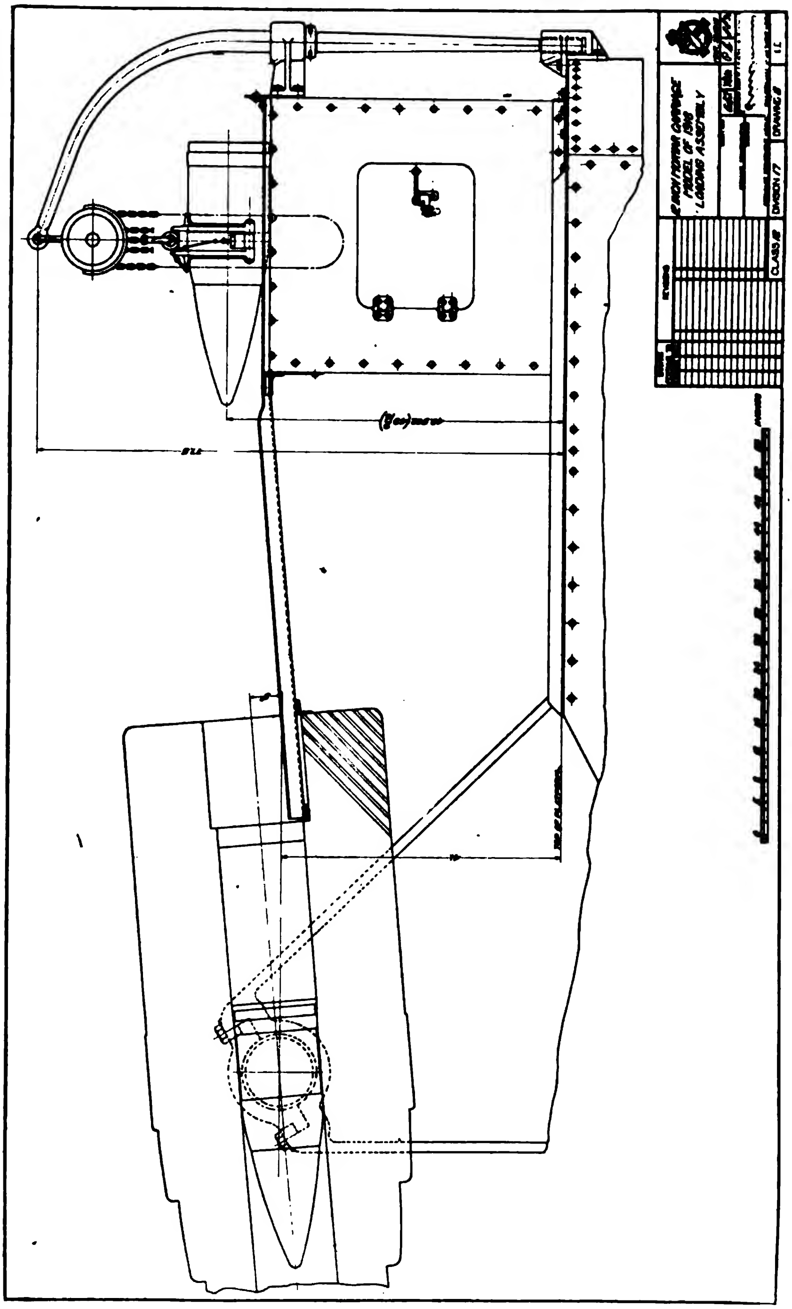

6 WHEEL TRUCK
M.C.B. OUTSIDE JOURNALS
GENERAL ARRANGEMENT
CLASS 16
DRAWING 2
FILE

PLATE 138



6.—AMERICAN 12-INCH GUNS ON BATIGNOLLES TYPE OF RAILWAY MOUNT. (19)

166. This mount is built on a design almost identical with the design of the mounts on which the French have placed 305 and 340 millimeter guns and 370-millimeter howitzers. Modifications were made in the French design to adapt the mount to American manufacture and the American guns. This type of mount, plates 26, 140, and 141 is a development of this war. It was designed by the Societé des Batignolles in France, during the latter part of 1914, and the first mount was tested at the Railway Artillery Camp in January or February of 1915. All mounts of this type rendered most excellent service throughout the war, proving definitely the merit of the design. The original American plan was to mount a number of 10-inch 34-caliber guns, models of 1888, 1888 Mark I and 1888 Mark II, on the same design of carriage. This has not and likely will not be done. It can be done at any time without great difficulty simply by providing a new cradle with decreased inside diameter and a slight modification of the throttling grooves and the recoil cylinders.

167. Guns.—The guns that are being used with these mounts are 12-inch, models of 1895 and 1895 Mark I, all of 35-caliber length. These guns are provided with the interrupted thread type of breech block which is fitted with a mechanical firing mechanism. The guns are provided with heavy splines on top and bottom, which not only prevent rotation of the gun on firing, but likewise carry the entire weight of the gun in the cradle; that is, the gun does not touch the cradle except in the spline ways. This is not considered good design, but the French practice was followed in preference to making any radical modifications in their design at a time when it was imperative that the guns be mounted with the least possible delay. Difficulties already experienced in proof firing indicate that unusually fine machine work is required on the splines and spline ways to prevent excessive friction and sticking of the gun before it has returned entirely to battery. The inside construction of the cradle with the spline ways into which the splines fit is shown on plates 142, 143 and 144.

168. Recoil Mechanism.—The recoil system is hydropneumatic and comprises two hydraulic recoil cylinders attached to the bottom of the cradle, and one pneumatic recuperator attached to the top, plates 37, 142, 143, and 144. The length of recoil is about 900 millimeters and no pit is required under the mount for firing at the highest elevation. The air required for the charging of the pneumatic recuperator is furnished in bottles. In field service extra bottles are ordinarily carried on the mount. The design of the pneumatic recoil is

essentially the same as that on the 12-inch mortar which has already been described in detail.

169. ELEVATING MECHANISM.—It is possible to elevate the 12-inch gun from minus 5 degrees to plus 36 degrees. The elevating mechanism is in duplicate with a rack attached to each side of the cradle and pinions connecting through slip friction devices, worm and wormwheels, spur gears, a shaft, miter gears, and chains to the handwheels. This mechanism is shown in detail on plate 145. Antifriction devices of the lever design are included in the mechanism. This can be seen in the view at the right on plate 145. The slip friction devices are a part of the wormwheels shown on plate 154 and in design are practically identical with that used on the 10-inch sliding mount, plate 113. For easy elevating of the gun, the antifriction device is kept so adjusted that a 0.002 thickness gauge can be inserted under the main trunnion. It will be observed on plate 145 that the two mechanisms are rigidly connected by a cross shaft on which the chain sprockets of each are mounted. One turn of the wheel moves the gun through 35 minutes in elevation.

170. TRAVERSING MECHANISM.—The gun and cradle are swung between the side frames of the structural steel top carriage which is pivoted on the pintle at its forward end to allow a slight traverse. The extent of this traverse is 5 degrees on each side of the center line. Two handwheels mounted on the sides of the top carriage at the rear connect by chains with a horizontal cross shaft and from this by bevel gears to a horizontal longitudinal shaft which drives the traverse pinion through a worm, wormwheel, and shaft. This mechanism is shown in detail on plate 146. The rack and pinion are shown in detail on plate 147. The location of the handwheel is shown more clearly on plate 148. The greater part of the weight of the gun and top carriage is carried on the pintle, at which point the friction is reduced through the use of a column of Belleville springs, shown on plate 54. No provision is made in the design for the reduction of the friction between the rear of the top carriage and the car body by any special mechanism. The rubbing surfaces are simply kept well oiled. The design of this contact at the rear is shown in the lower right hand view on plate 146.

171. GUN CARRIAGE.—The gun carriage includes the recoil, elevating and traversing mechanisms described above, and two structural steel side frames with their connecting transoms to which these parts are assembled. This carriage is pivoted on the main girder by a heavy pintle which takes the horizontal component of the shock of firing, but normally the weight is supported on a smaller spring-supported pintle to reduce the friction of traversing. The pintle design is shown on plate 54. The general design of the top carriage is shown on plates 144, 147, and 148.

172. Car Body.—The car body consists of two plain plate girders of ordinary design connected by suitable transoms and provided with an operating platform at the rear. The exterior car body design is shown on plate 143. The connecting transoms can be seen in the section given on plate 54.

173. Anchorage.—The anchorage consists of a special ground platform made up in six sections and carried on a special ground platform car. Each section consists of a large structural steel spade and three wooden ties across which two running rails and two supporting girders are fastened, plate 150. As noted above, these sections are carried in the special car, plates 151 and 152, which is provided with a special mechanism for placing the sections, and taking them up and loading them. In placing a platform, a section of the railway line of the required length is removed, pits are dug for the spades and lined with sand or fine stone. The platform car is then run up to the end of this space and one section after another is put down, end to end, and bolted together. After one section is placed, the platform car is run on to that section for the placing of the next. On plates 153 and 154 a complete platform is shown installed and ready for the placing of the mount.

174. When the platform has been bolted up and the sand and rock well tamped around and under the ties and spades, the mount is run on and so placed that 12 sets of clips, which can be seen on the bottom of the lower cords on the side girders, plate 26, are just over the similar sets of clips on the supporting girders of the platform, plate 153. The 24 special wedges (12 on each side), which are carried on the hooks which can be seen on the sides of the girders near the lower cord, plate 155, are then placed between the car girders and the platform girder and the mount is well wedged up and later bolted to the platform. The wedges are each composed of three triangular wedge-shaped sections, the middle one of which can be moved with respect to the other two by a screw. The turning of the screw forces the center wedge up and the other two wedges both out and down, thereby lifting a portion of the weight of the mount from the trucks and attaching it rigidly to the platform through the clips. This type of platform is particularly rigid and no displacement whatever can ordinarily be observed even from very heavy firing. It was a French practice to provide each mount with two platforms both of which could be placed near each other in a curved railway line, thereby giving a total traverse of 20 degrees on the two platforms. The writer has seen a platform placed in two hours after the section of track had been opened and pits for the spades had been prepared. Much less time is required for their removal.

175. Trucks.—The trucks, two in number, are eight-wheel locomotive type with inside journals, and the bodies are made up entirely of structural steel. The journals are 6.693 by 12.2 inches and the wheels 36.22 inches in diameter. The trucks are equipped with both hand and air brakes. It will be observed that they are fitted with the French type of buffer, plate 158. This was intended for service in France. These buffers and couplings have since been replaced by the standard M. C. B. type. The original center-pin design, which can be seen on plate 54, was found to be unsatisfactory for service on American roads, since it can not stand the strain of bumping of the average American train. This has been modified to the heavy center-plate design typical of American standard car equipment.

176. Ammunition Supply System.—The ammunition car used with the Batignolles mounts is identical in design to that employed with 8-inch railway mounts, plates 106 and 107. In service, this ammunition car is placed directly behind the mount, plate 54. The ammunition is placed on the operating platform of the mount by means of the ammunition trolley. It is then picked up by the jib crane, the design of which is shown in detail on plate 159, and transferred to a loading stand at the rear of the gun, plate 160, from which it is slid down into the gun on a removable tray. The gun is loaded at 5 degrees depression, the projectile being rammed by hand. The design of the loading apparatus on the working platform of this mount is very radically different from that provided on the French Batignolles mounts, plate 162. On the French mount the projectile is received directly from the ammunition car and drawn up to the tray at the top of the inclined elevator. When this tray, which is shown in an approximately horizontal position, is tipped up at the rear, the projectile slides forward onto the ammunition stand which can be moved back against the elevator. This ammunition stand is then rolled forward by means of two handwheels, one of which can be seen on the right hand side of the stand, bumping the breech of the gun very hard. The projectile starts to slide into the breech of the gun and is rammed by a mechanical rammer, operated by the same two handwheels. It is felt that the simple modified design is decidedly an improvement over the elaborate French design. A closer view of the ammunition stand, breech of the gun, removable tray, projectile tray, and powder bag of the American mount can be seen on plate 161.

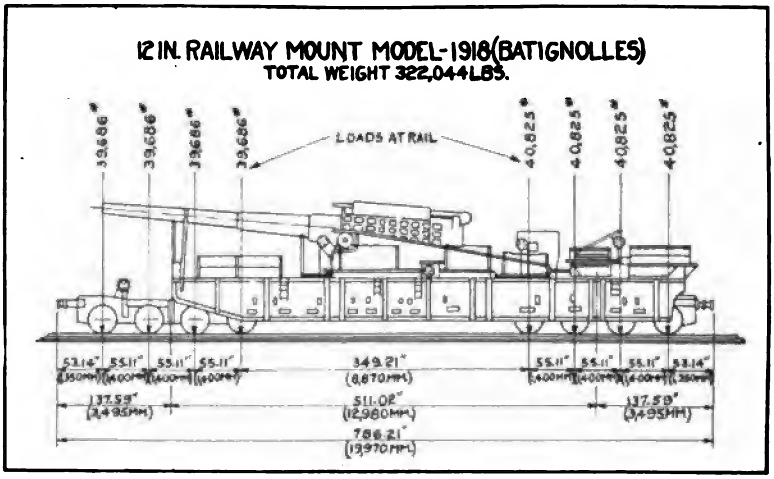
177. Maintenance.—No difficult problems of maintenance presented themselves to the French service on similar mounts, and it is assumed that no serious difficulties will be experienced by the American service. It will likely be necessary to check up occasionally on the adjustment of the anti-friction devices to be certain that the elevating mechanism is working at maximum efficiency.

178. Difficulties Involved in Service.—It can not be said that there are any particular difficulties involved in the service of this design of mount. If the special ground platform car is kept in fine working order the platform sections are not difficult to place, and the time consumed in placing the platforms can not be said to be excessive. One group commander with whom the writer was able to consult a number of times had been in charge of this type of artillery since it had been placed in the field in 1915. He was a naval officer and he was operating his artillery with navy personnel. He was most enthusiastic about the Batignolles design and was positive that he had never experienced any serious difficulties either of maintenance or service. A very striking attitude of commanders who had operated continuously either the Batignolles or the Glisement type mounts was that each had become so thoroughly convinced that the type that he was operating was the only type worth having that he could not conceive of a reason for constructing any other kind. This was especially so of the personnel operating Batignolles mounts. Although they had to admit that the sliding type mounts were giving good service in the field, they could not bring themselves to believe that it was a type of artillery on which construction should continue. The personnel operating sliding artillery held exactly the same point of view regarding their mounts.

179. Merits.—The merit of this design is that it is exceedingly well balanced. It is true that there seems to be an excess of equipment in the ground platforms and platform cars, but with guns of this caliber it is necessary to have a mount that is either provided with a stable foundation or that can be operated on a curved track. The difficulties incident to operating railway mounts on curved tracks are sometimes very great, and it is felt that what might be termed excessive equipment in the platforms and platform cars, is less objectionable than the difficulties involved in the laying of curved tracks. This type of platform can be installed more rapidly than any other existing type of platform for so heavy a gun.

180. Demerit.—The demerit of this mount, if it may be styled such, is the very elaborate ground platform and platform car. It seems quite probable that guns of this caliber might be placed on mounts in which the horizontal component of the force of recoil can be transmitted to the ground by means of struts at the rear, somewhat similar to those used with 8-inch gun and 12-inch mortar mounts. This would likely necessitate the provision of some jacking equipment for lowering the mount, until portions of it were in contact with the service rails or with auxiliary rails, for transmitting the vertical component of the force of recoil into the track by other channels than through the trucks, but this would not be difficult. If such a design can be made, and preliminary investigation indicates that it can, then the Batignolles design is too elaborate.

PLATE 139


12 IN. RAILWAY MOUNT MODEL-1918 (BATIGNOLLES)
TOTAL WEIGHT 322,044 LBS.
LOADS AT RAIL
39,686#
39,686#
39,686#
39,686#
40,825#
40,825#
40,825#
40,825#
53.14"
55.11"
55.11"
55.11"
349.21"
(8,870MM)
55.11"
55.11"
55.11"
53.14"
137.59"
(3,495MM)
511.02"
(12,980MM)
137.59"
(3,495MM)
786.21"
(19,970MM)

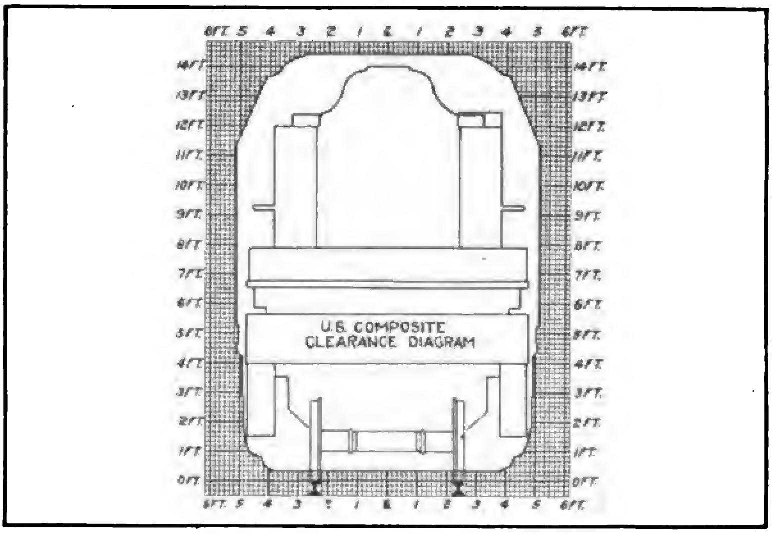
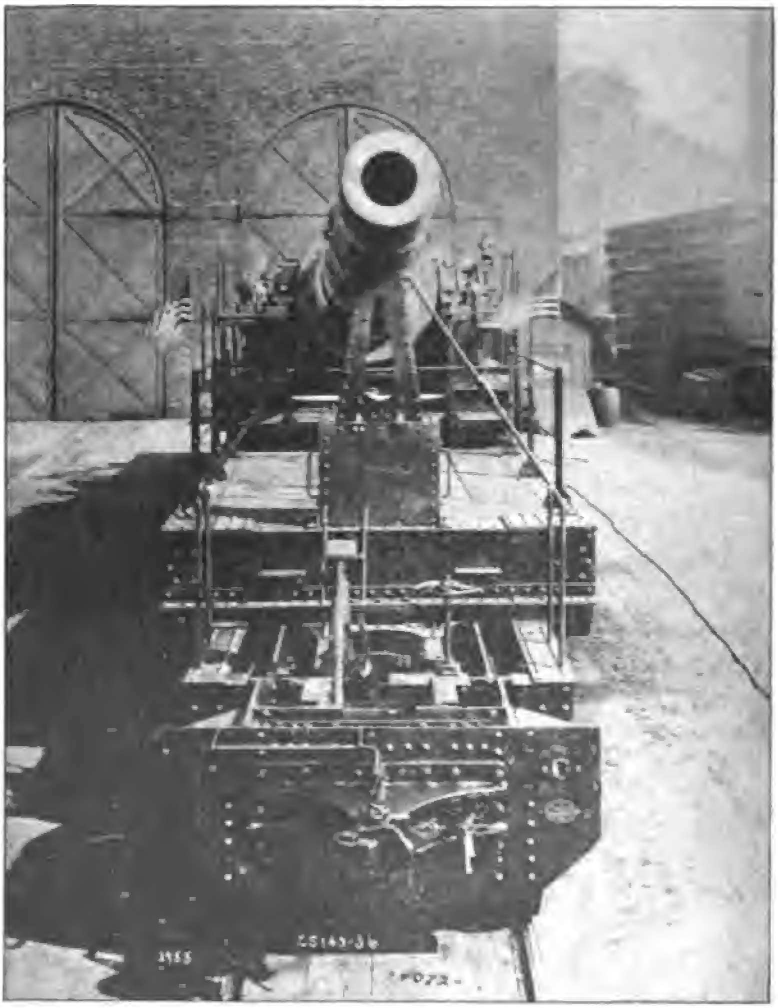

U.S. COMPOSITE
CLEARANCE DIAGRAM

PLATE 140

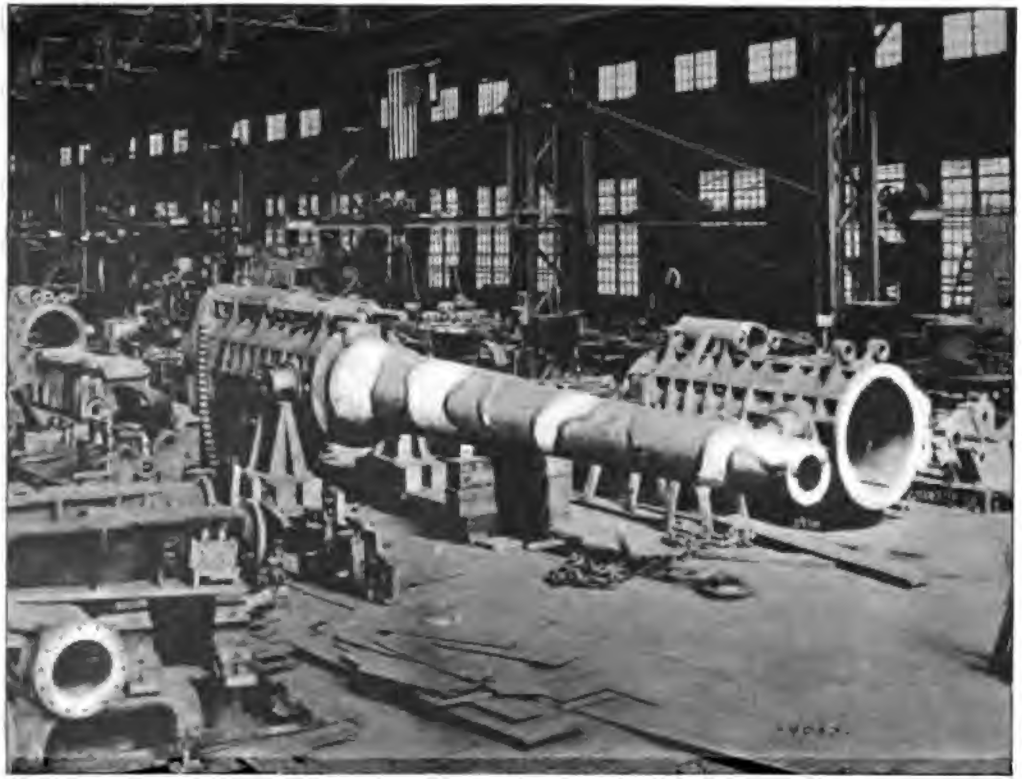
12-INCH, 35-CALIBER GUN ON BATIGNOLLES RAILWAY MOUNT.

PLATE 141



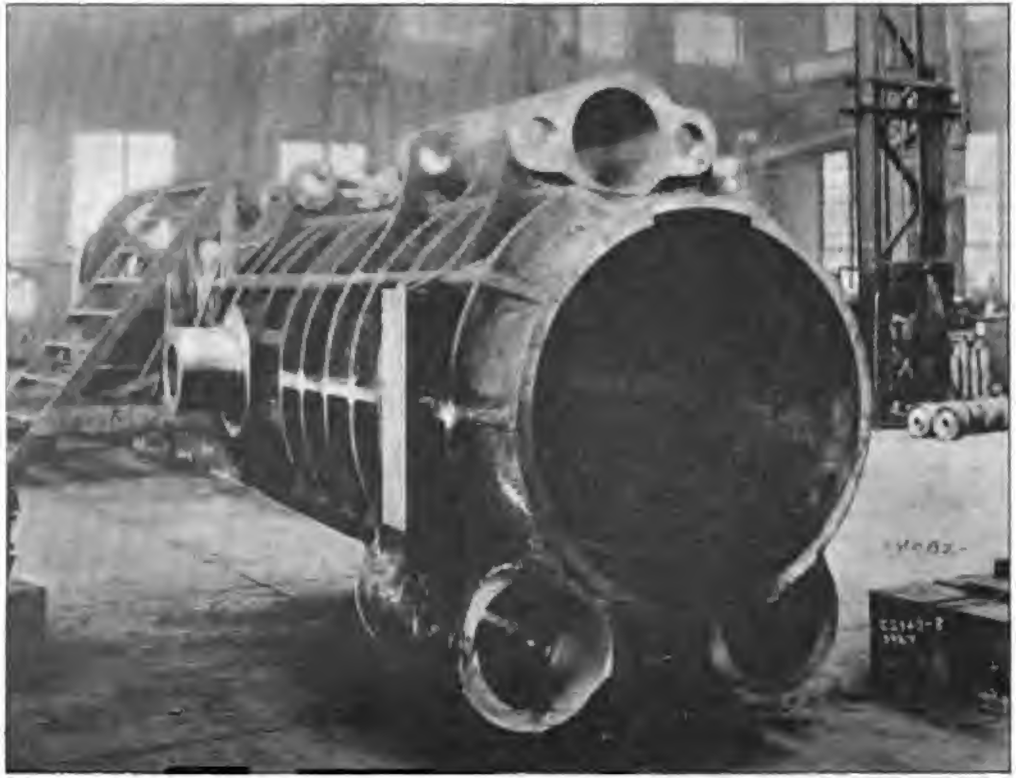
12-INCH, 35-CALIBER AMERICAN GUN ON BATIGNOLLES MOUNT.

PLATE 142



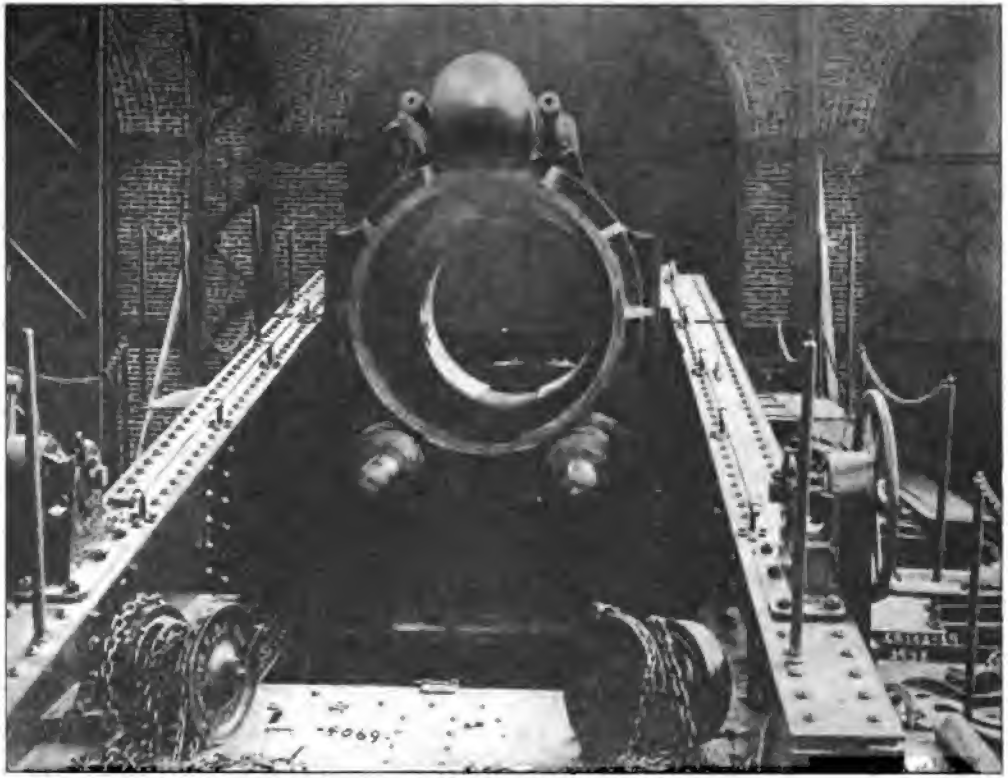
CRADLE RECUPERATOR AND RECOIL MECHANISM OF THE 12-INCH, 38-CALIBER AMERICAN GUN MOUNT.

PLATE 143



CRADLE OF THE 12-INCH, 35-CALIBER AMERICAN GUN MOUNT.

PLATE 144



CRADLE RECUPERATOR AND RECOIL MECHANISM OF THE 12-INCH, 35-CALIBER AMERICAN GUN MOUNT.

181768—21——14

PLATE 145

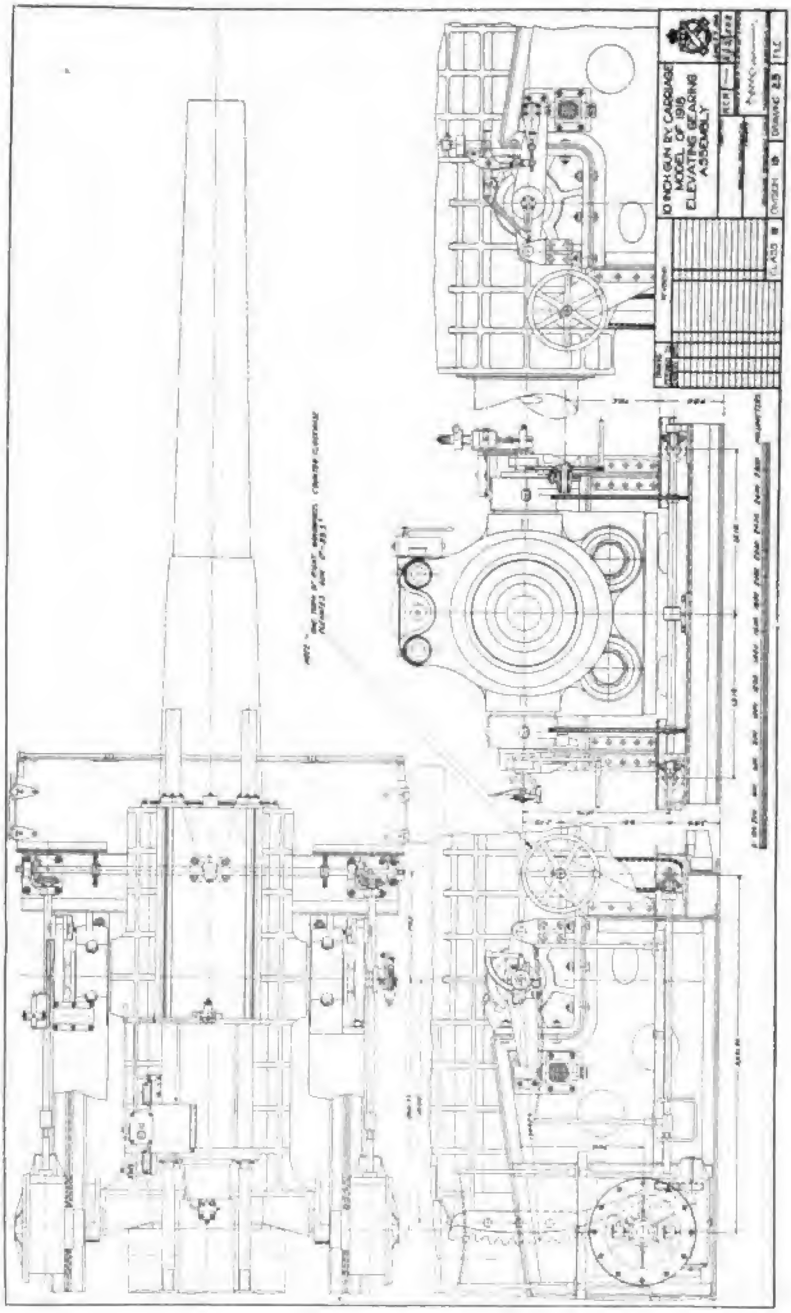

10 INCH GUN BY CARRIAGE
MODEL OF 1916
ELEVATING GEARING
ASSEMBLY

PLATE 146

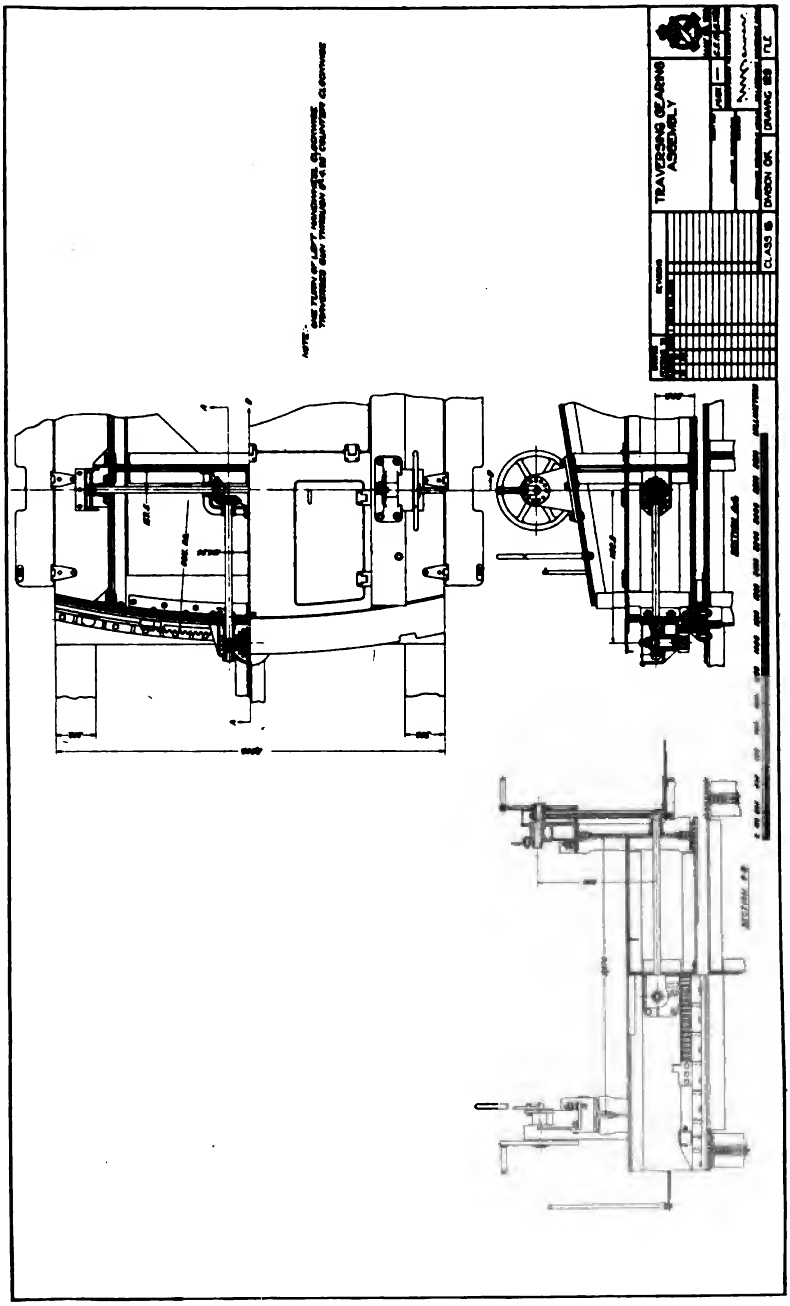
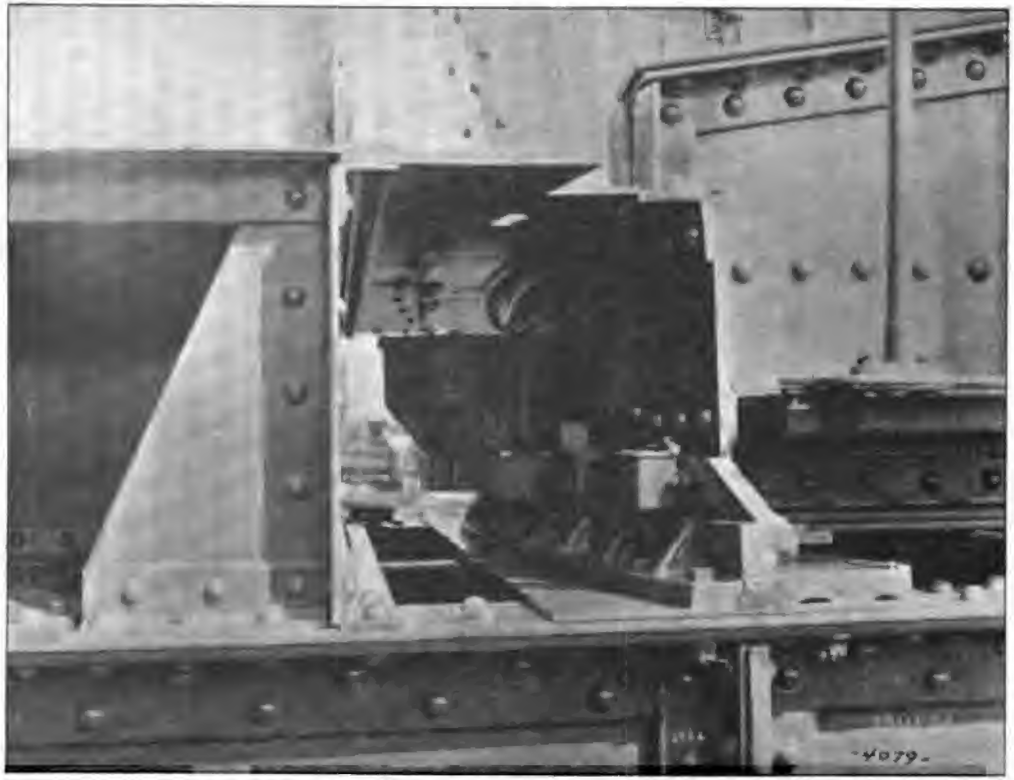
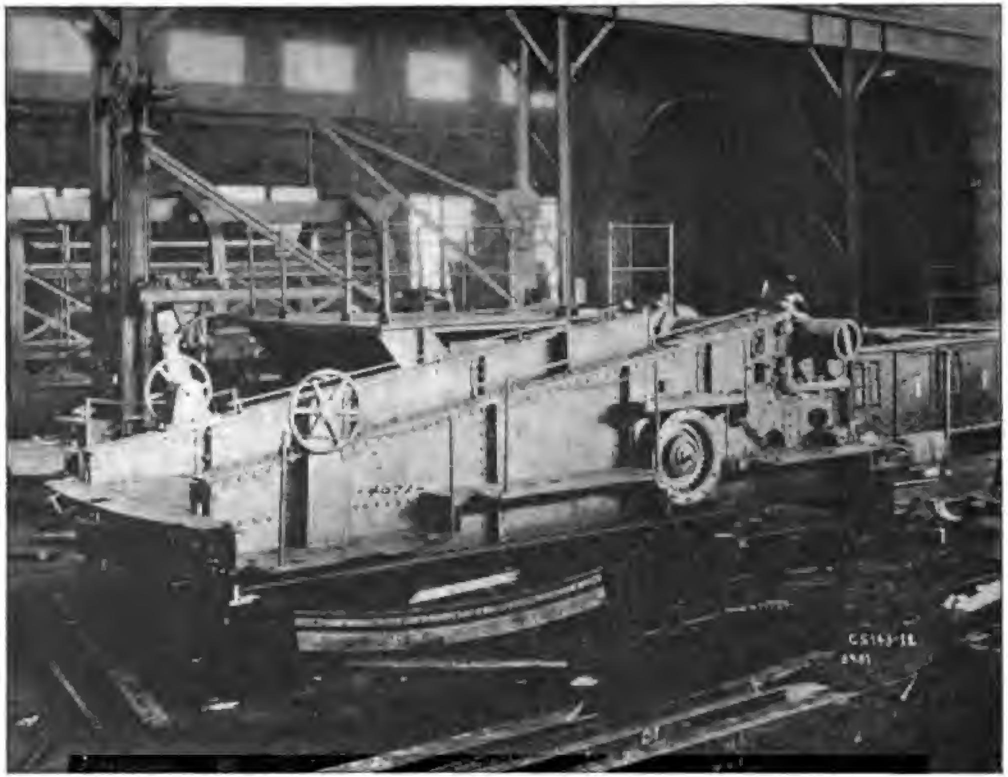


PLATE 147



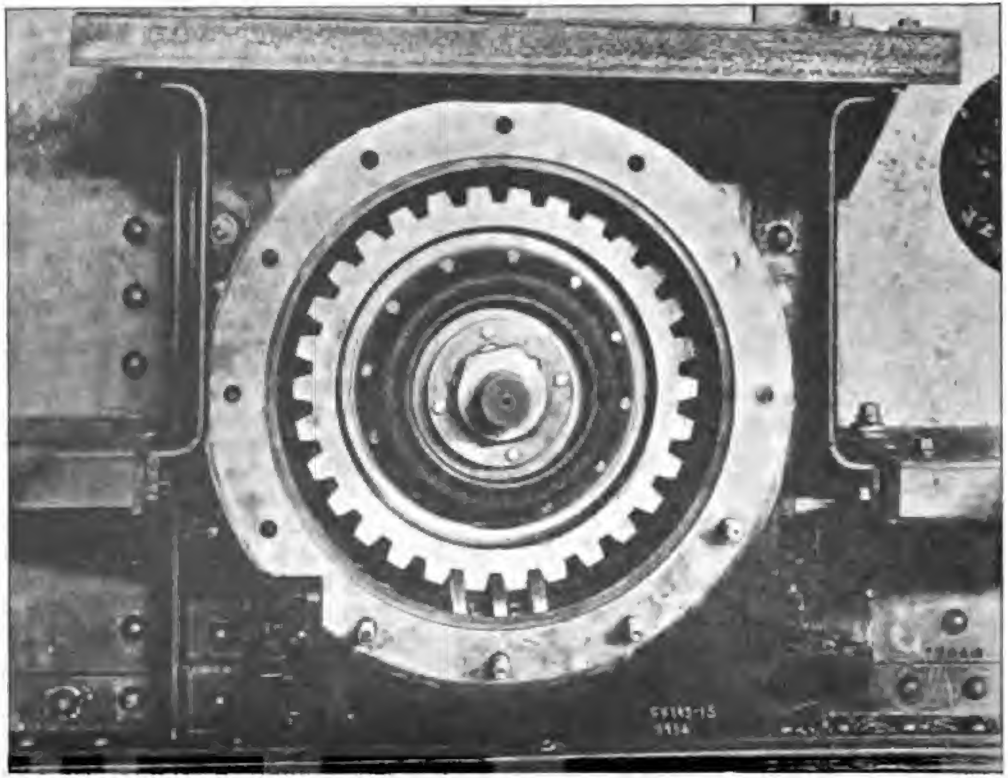
RACK AND PINION OF THE TRAVERSING MECHANISM OF THE 12-INCH, 35-CALIBER AMERICAN GUN MOUNT.

PLATE 148



TRAVERSING HANDWHEELS OF THE 12-INCH, 35-CALIBER AMERICAN GUN MOUNT.

Plate 149



ELEVATING WORM WHEEL AND SLIP-FRICTION DEVICE OF THE 12-INCH, 35-CALIBER AMERICAN GUN MOUNT.

PLATE 150

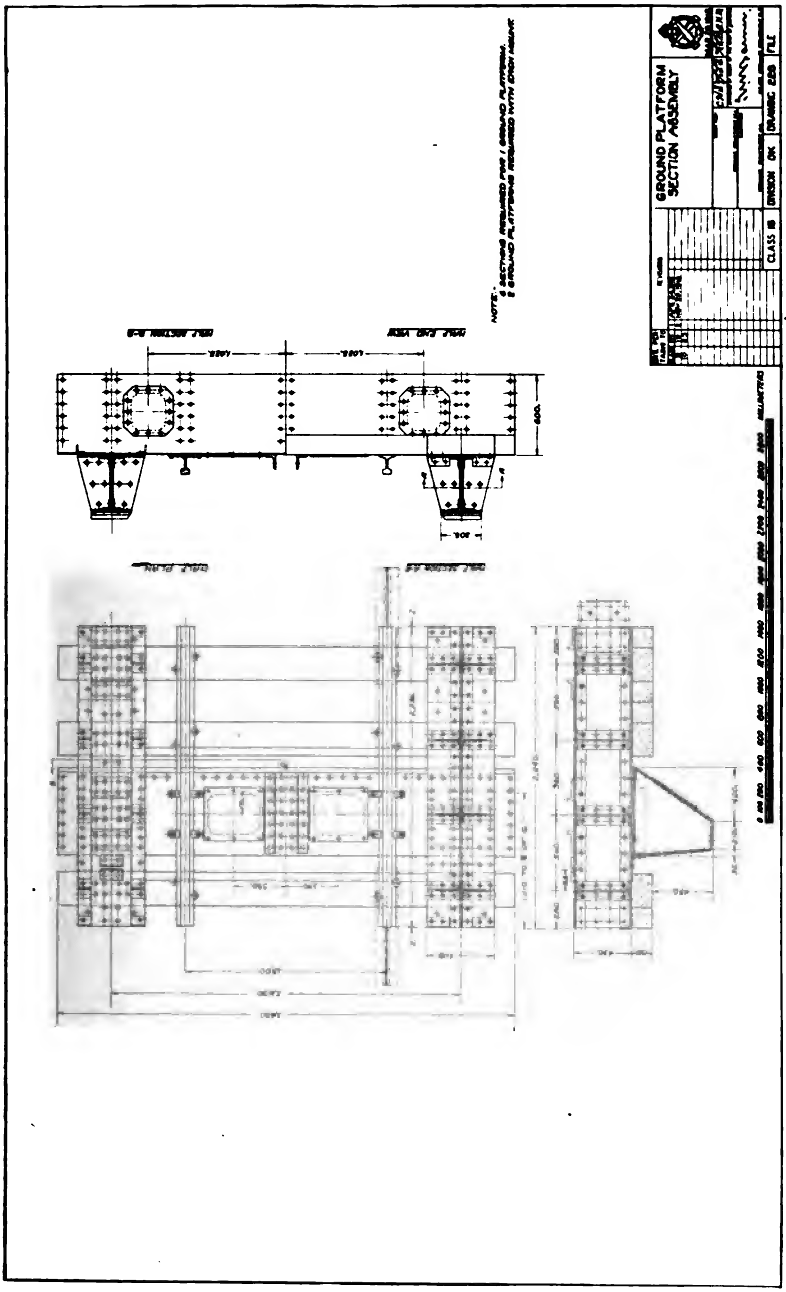
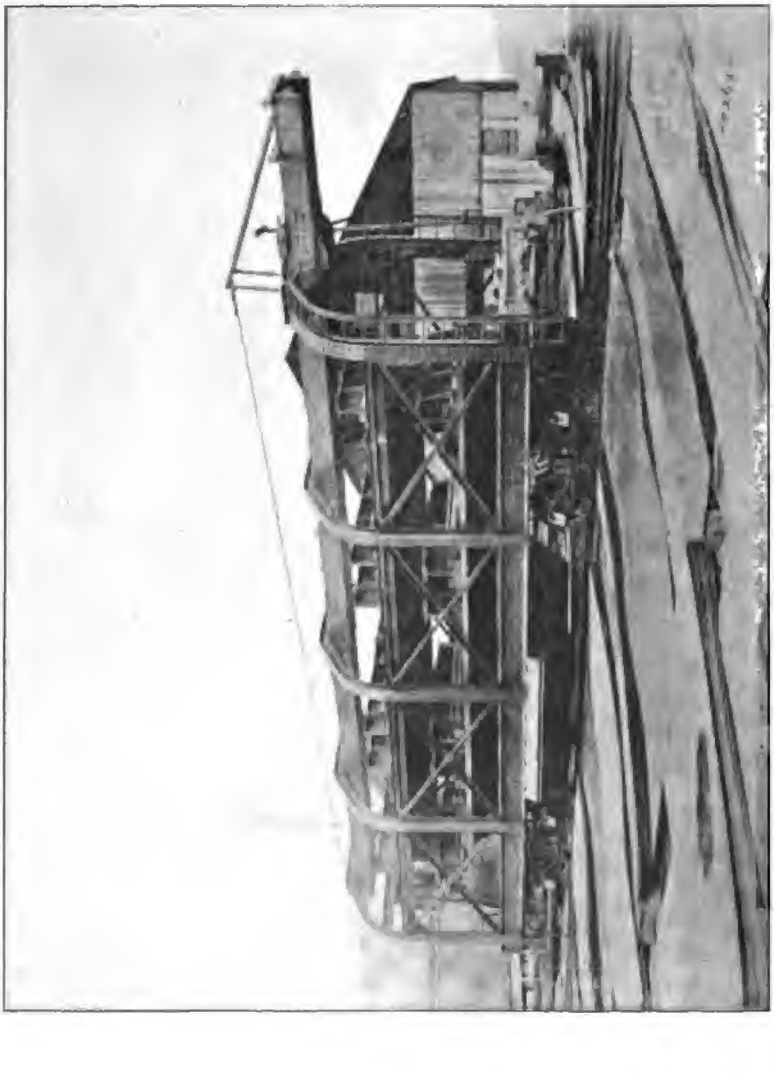


PLATE 151

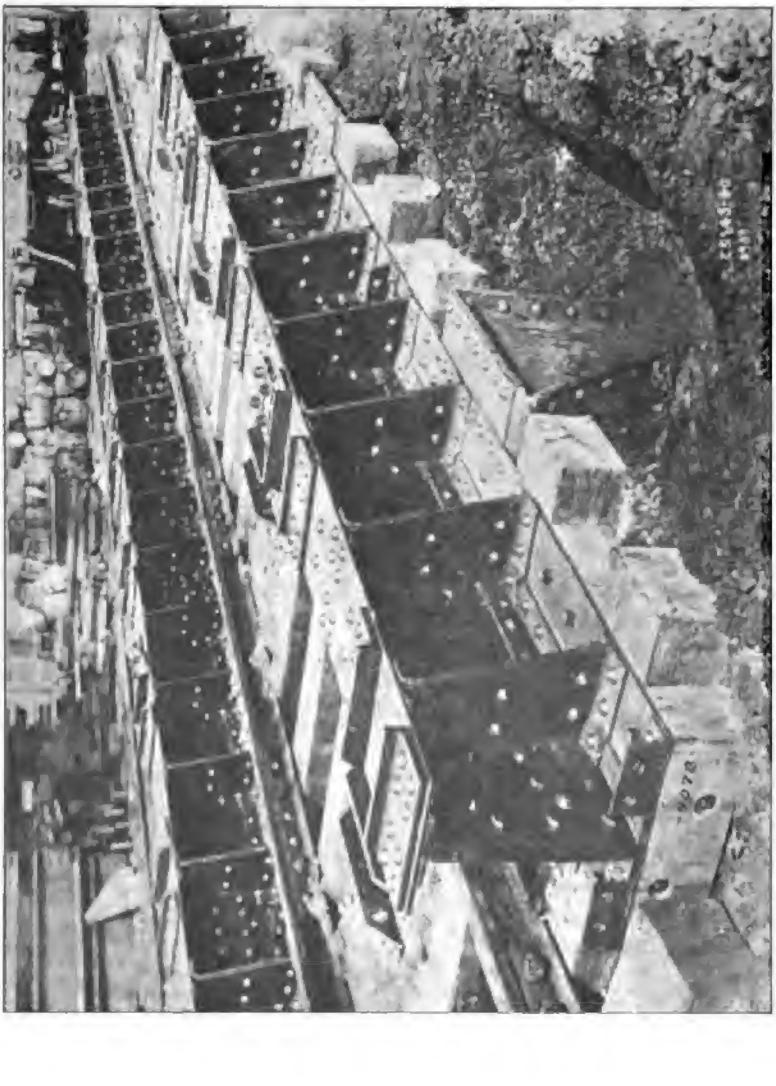


FIRING PLATFORM CAR FOR THE 12-INCH, 35-CALIBER AMERICAN GUN MOUNT.

Plate 152

FIRING PLATFORM CAR FOR THE 12-INCH, 35-CALIBER AMERICAN GUN MOUNT.

PLATE 153

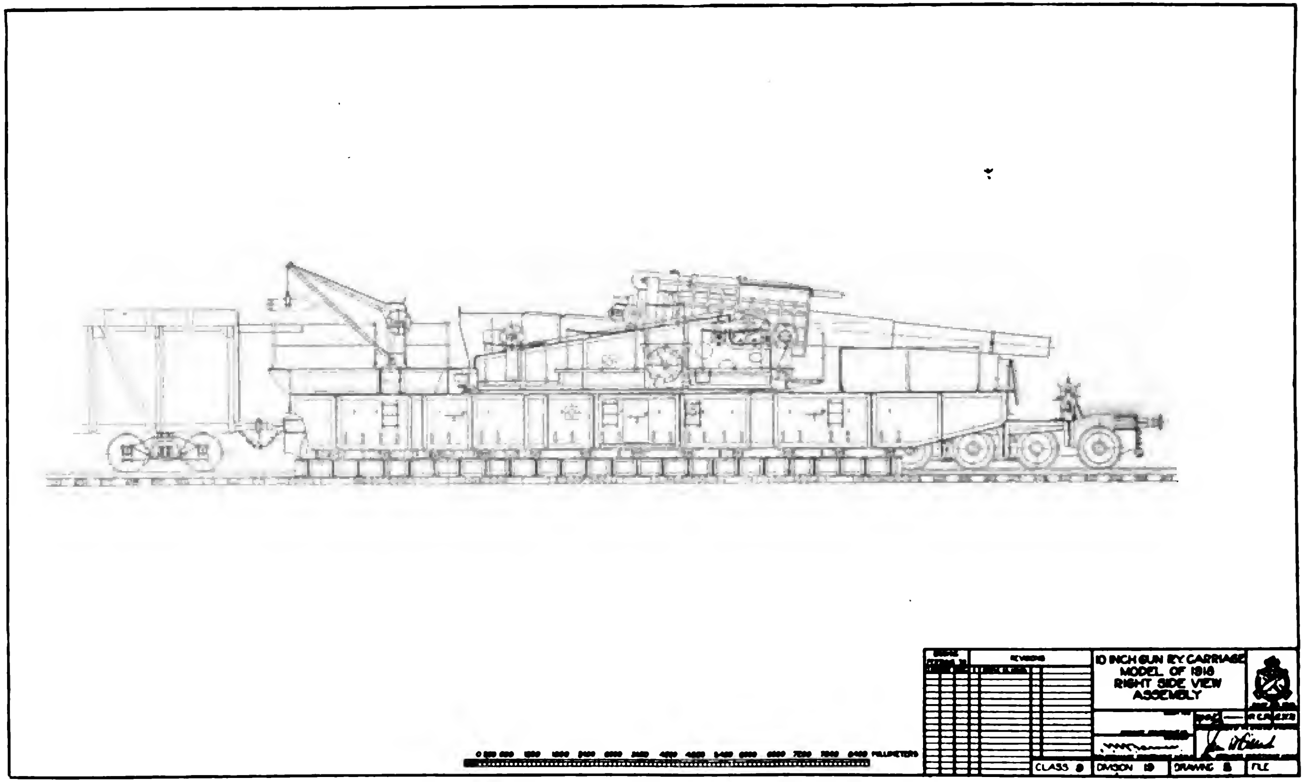


FIRING PLATFORM FOR THE 12-INCH, 35-CALIBER AMERICAN GUN MOUNT.

PLATE 154

FIRING PLATFORM FOR THE 12-INCH, 35-CALIBER AMERICAN GUN MOUNT.

PLATE 155



12-INCH, 35-CALIBER AMERICAN GUN MOUNT ON ITS FIRING PLATFORM.

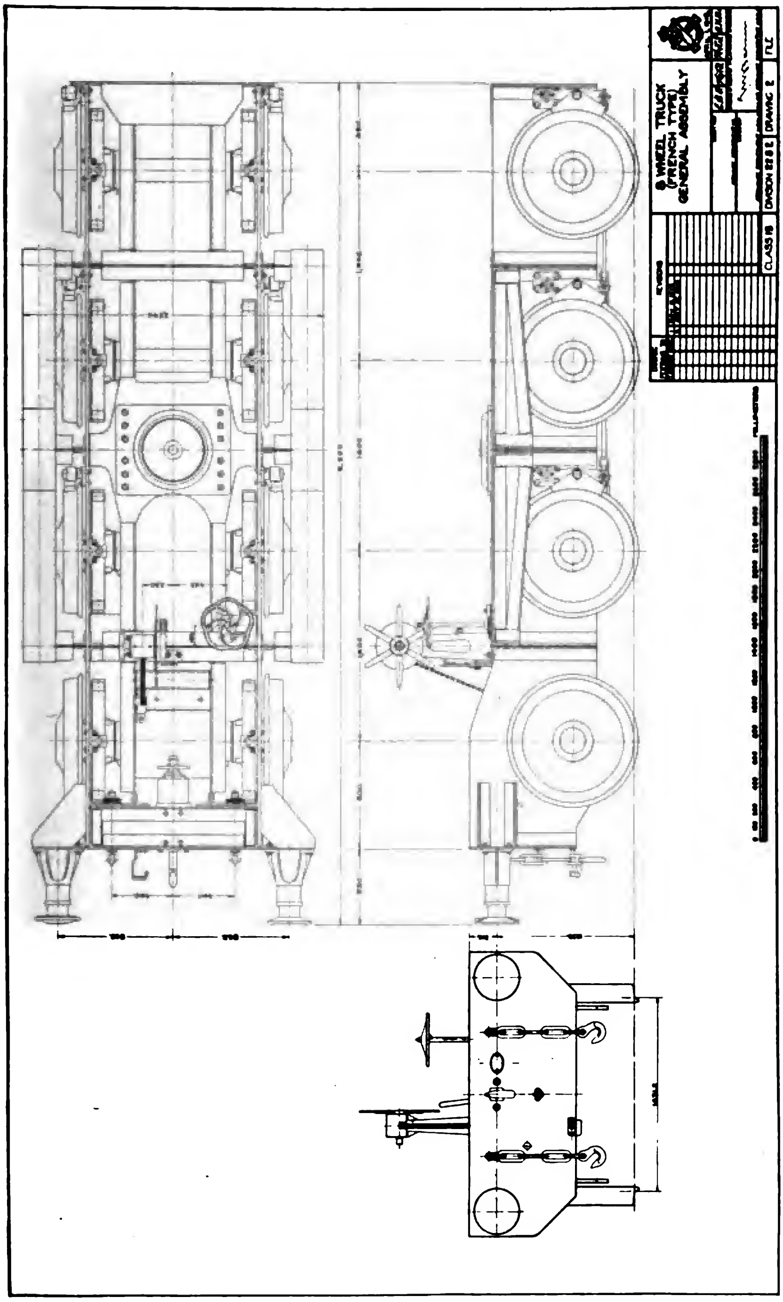
PLATE 156

12-INCH, 35-CALIBER AMERICAN GUN MOUNT ON ITS FIRING PLATFORM.

Plate 157

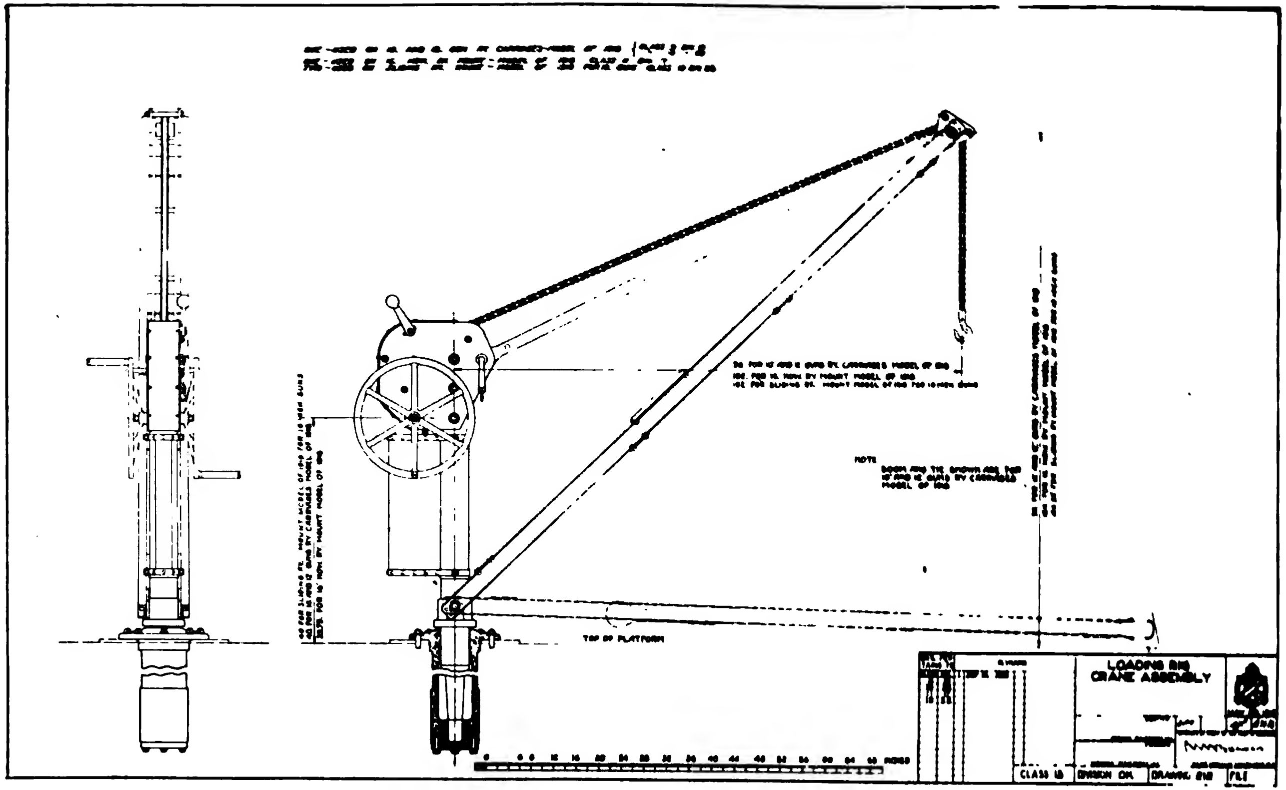
12-INCH, 35-CALIBER AMERICAN GUN MOUNT, AMMUNITION AND PLATFORM CARS.

Plate 158



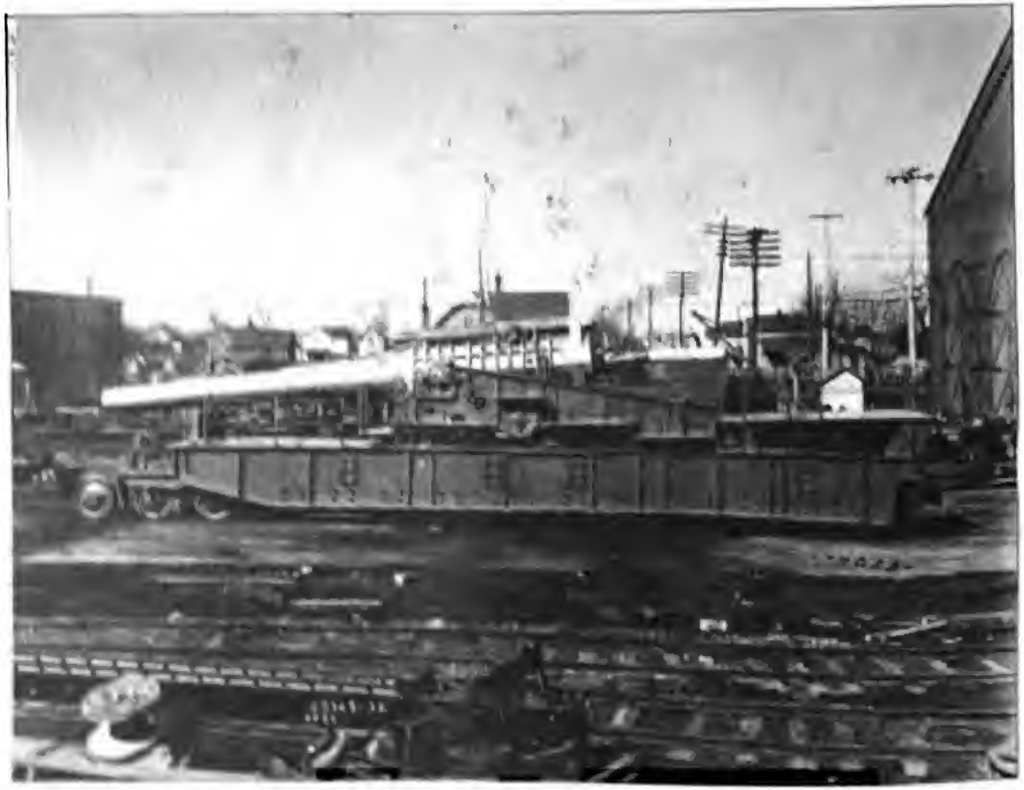
TRUCK FOR THE 12-INCH, 35-CALIBER AMERICAN GUN MOUNT.

PLATE 150



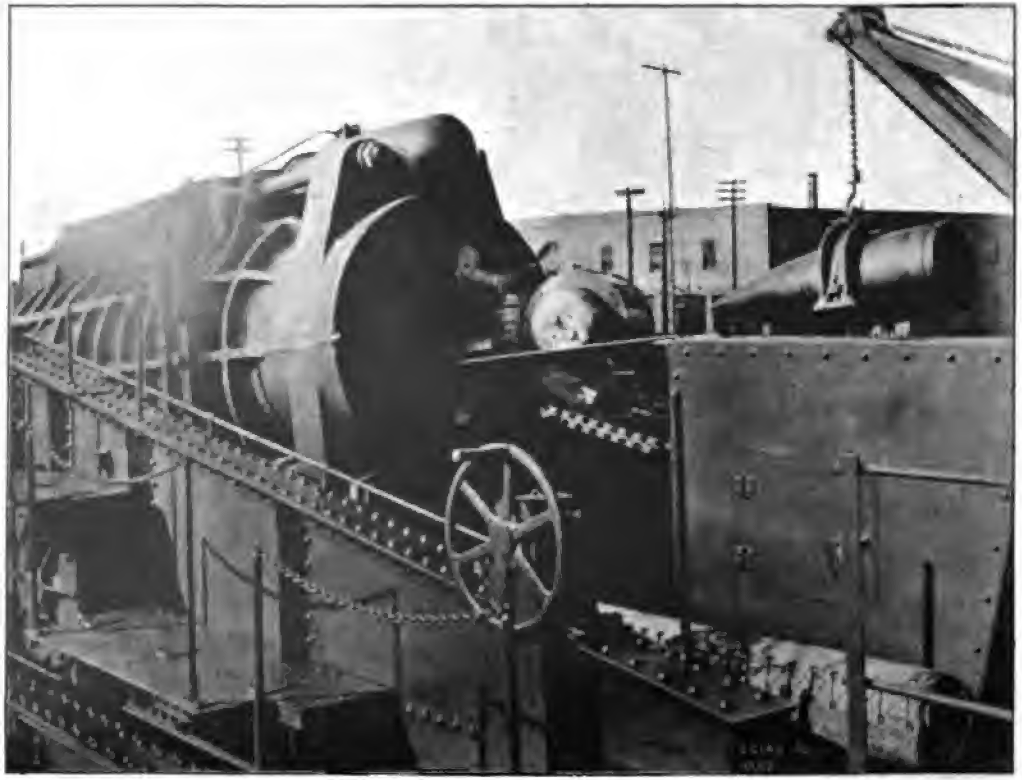
AMMUNITION CRANE OF THE 12-INCH, 35-CALIBER AMERICAN GUN MOUNT.

PLATE 160



LOADING TABLE FOR THE 12-INCH, 35-CALIBER AMERICAN GUN MOUNT.

PLATE 161



LOADING TABLE AND TRAY OF THE 12-INCH, 35-CALIBER AMERICAN GUN MOUNT.

370-MM. FRENCH HOWITZER ON BATIGNOLLES MOUNT.

7.—AMERICAN 12-INCH 50-CALIBER GUN ON RAILWAY MOUNT. (20)

181. This mount is of the French Glissement or sliding type modified to suit the American war-time manufacturing conditions. The gun rests in trunnion bearings rigidly connected to the main girders of the mount. A general view and details are shown on plates 163 to 184.

182. Gun.—The piece used with this mount is a 12-inch gun, model of 1918, Bethlehem, of 50 calibers length, plate 15. It is equipped with fixed trunnions and counterweight on the breech end, plate 165, to allow mounting the trunnions as near the breech as possible. The breech block is of the Welin or step thread type, plates 169 and 170.

183. Recoil Mechanism.—No recoil mechanism, in the ordinary sense of the term, is used with this mount. The gun is fixed to the girders, as noted above, and the entire mount slides back along the track as a unit under the shock of recoil. Description of the arrangement by which this is accomplished is given under "Anchorage." Counter-recoil is accomplished by the same mechanism as traverse.

184. Elevating Mechanism.—Elevation from the loading position, minus 4 degrees to plus 40 degrees, is secured through a segmental circular rack attached to one side of the counterweight on the breech of the gun. The pinion meshing with this rack connects through a slip-friction device, a worm and wormwheel and sets of bevel gears with two handwheels located on top of the two side girders. Any excessive thrust due to fire is taken up by the slip-friction device and no dangerous strain can come on the gear. One turn of the handwheel moves the gun through 0.625 degrees in elevation. Details of this mechanism are shown on plate 172.

185. Traversing Mechanism.—No provision is made on this mount for traversing the gun: pointing in azimuth is accomplished by translating the entire carriage along the curved firing track. To accomplish this, two translating mechanisms are provided, one on each of the two inner eight-wheeled trucks. Each translating mechanism consists of a train of four gears and two sets of sprockets and chains connecting the operating handwheel with one axle of the truck, plate 117. The total ratio is 100 turns of the handwheel to one turn of the truck wheel and on the shop test of the carriage, four men on each operating handle moved the mount at the rate of about 3 feet per minute. It is probable that this performance will be materially improved as the apparatus is limbered up by use. A clutch is provided between the gear train and the chain so that the gears can be disconnected when the piece is fired. This is necessary in order to avoid excessive speed in them as the car moves backward in recoil. For traveling considerable distances, the chain between truck axle and the rest of the mechanism is removed on all mechanisms.

186. An alternative power translating arrangement is provided on the front span bolster of the mount. This comprises a 50-horsepower gasoline engine and winch which are capable of exerting a pull of about 7,000 pounds; cable and sheaves are provided so that this may be multiplied to the extent necessary to move the mount. It is not possible to readily move the mount backward with this apparatus, but if the mount is pulled somewhat too far forward, it can be run back by the hand translating mechanism. One of the mounts, plate 168, is equipped with electric motors for driving the translating mechanisms; the power is supplied from a 25-kilowatt gasoline generator set mounted on a special recoiling base on the rear of the working platform. It is possible to move the mount either forward or backward by these motors.

187. Gun Carriage.—In this mount the gun carriage and car body are incorporated in a single unit and are described in the next paragraph.

188. Railway Car Body.—The railway car body consists of two large box girders built up of structural steel and connected by transom plates. These girders are carried on span bolsters, plate 164, each of which, in turn, rests upon two trucks. Cast-steel trunnion bearings are mounted on top of the girders and are provided with an antifriction device which supports the gun on small trunnions for elevating or depressing, but allows strains to be transmitted directly to the main trunnion bearings during firing. Operating platforms, loading apparatus, etc., are also provided on the car body. The main girders rest upon span bolsters through a special center plate and king bolt arrangement with removable center and side bearings. A lever is provided on the side of the span bolster, plate 176, by moving which these bearings can be withdrawn, so that a vertical movement of 5 inches between girder and span bolster is possible. This is provided so that any possible sinking of the track and consequent lowering of the main girder can not bring undue strain upon the truck.

189. Anchorage.—As noted above, this carriage is of the sliding type and is not rigidly braced against the ground. It is fired from a specially prepared track laid with extra long ties upon which are set up eight lines of 12-inch, 55-pound steel I beams called bearing stringers, plate 177. The weight of the mount is transferred from the trucks to these stringers by means of 10 sleepers, which are special wooden beams attached crosswise under the main girder. These are attached to the main girder through lifting wedges, which permit them to be lowered, so that they press upon the bearing stringers, or raised, so that they clear and the weight of the mount is taken by the trucks, plate 178. The lifting wedges, one of which is provided at each end of each sleeper, consist of a fixed casting fastened to the underside of the side girder, a movable wedge attached to the sleeper and capable

of vertical movement only, and a second movable wedge between these two, which can be moved horizontally by means of a screw threaded through its center, bevel gears, and operating lever. As the lever is turned, the upper wedge is moved along by the screw and the lower wedge with sleeper is raised or lowered accordingly. Each sleeper consists of a plate steel carrier into which are bolted three heavy wooden beams at each end. While the gun is in action the two ends of the sleeper are supported on the lower wedges of the lifting-wedge mechanism described above. For traveling the sleepers are slid out sideways with the help of sleeper cranes and are loaded separately. For firing the special track with bearing stringers as above described is laid on an 11-degree, 48-minute curve. The mount is pushed approximately to position on this track by means of a locomotive and is adjusted exactly by the translating mechanism. The sleepers are inserted and the weight of the mount is transferred largely to them by the operation of the lifting wedges. The gun is then fired and the mount slides backward along the track for a short distance. The wedges are raised and the mount is run forward to its original position by the translating mechanism, or by the gasoline winch already mentioned. Except for the span bolster center plate arrangement and the character of the wedge mechanism, this anchorage arrangement does not differ materially from that employed in the 10-inch sliding mount.

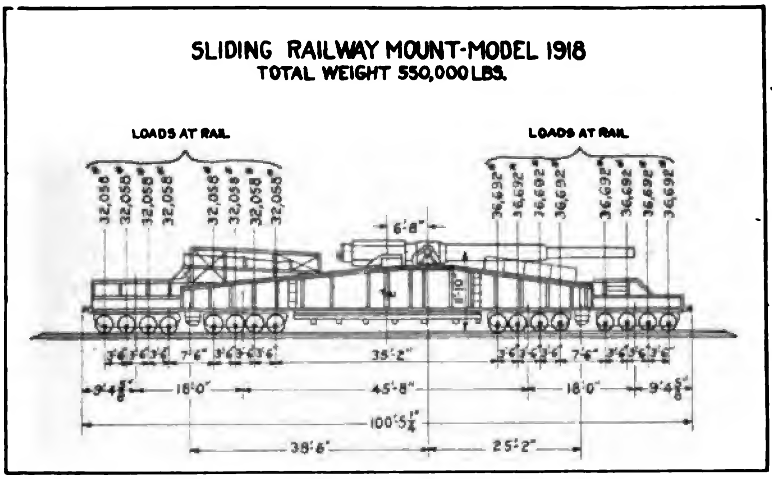
190. Trucks.—Four eight-wheel trucks, plate 179, are provided for this mount. They have structural side frames, cast-steel bolsters, 5.5 by 10 inch journals, and 30-inch wheels. The two outermost trucks are provided with air brakes, plate 180, and the two innermost with translating mechanism, as described under Traversing mechanism. Semi-elliptic springs are provided over each journal box.

191. Ammunition Supply System.—The ammunition car used with this mount, plate 181, is the standard Railway Artillery ammunition car. Special fixtures are provided, however, plate 182, for the 12-inch ammunition. The car is kept down the track at some distance from the mount itself, and a special shuttle car, plate 183, which is pushed by hand, is employed in transferring ammunition from the ammunition car to the mount. In use the shuttle car is run up against the end of the ammunition car and the trolley in the latter is run out over it. Ammunition is picked up from the interior of the car, run out, and let down directly on the shuttle car. The shuttle car is then pushed along the track by hand to the mount. The ammunition is picked up by means of the jib crane mounted on the rear span bolster and is transferred to an ammunition tray which runs on an inclined track from the back end of the main girders to the breach of the gun. This tray is provided with a buffer, so that when it is released it may run down the track and be stopped at the breech of

the gun without undue shock. The projectile slides on and seats itself in the gun. The loading angle is minus 4 degrees. The general arrangements for loading, as described above, are shown on plate 184.

192. MAINTENANCE.—Experience in hauling the mount over the road has shown that there is considerable weaving of the two side girders relative to each other which causes binding of the trunnion bearings. A complete steel plate decking is being added along the top of the girders to eliminate this. A similar weaving in French mounts has resulted in the breaking of trunnion caps. None of the mounts has yet seen sufficient service to develop serious troubles except as just noted. It is probable when these difficulties are remedied that no serious problems of maintenance will present themselves in field service.

PLATE 163



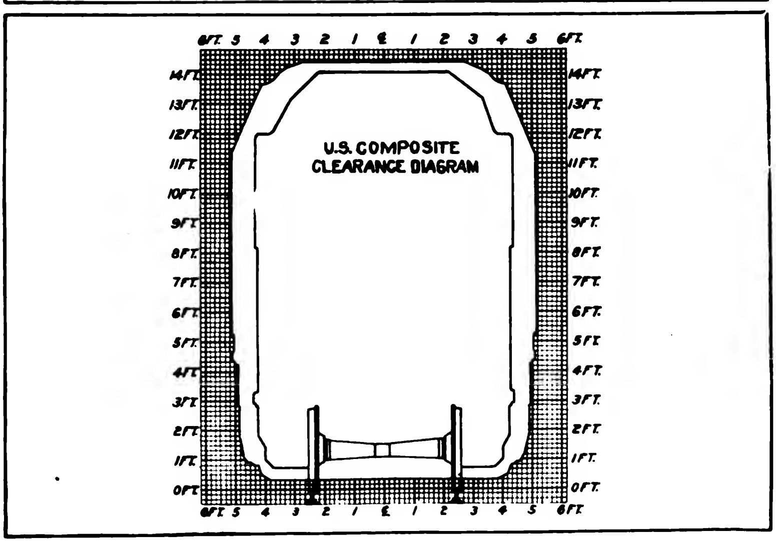
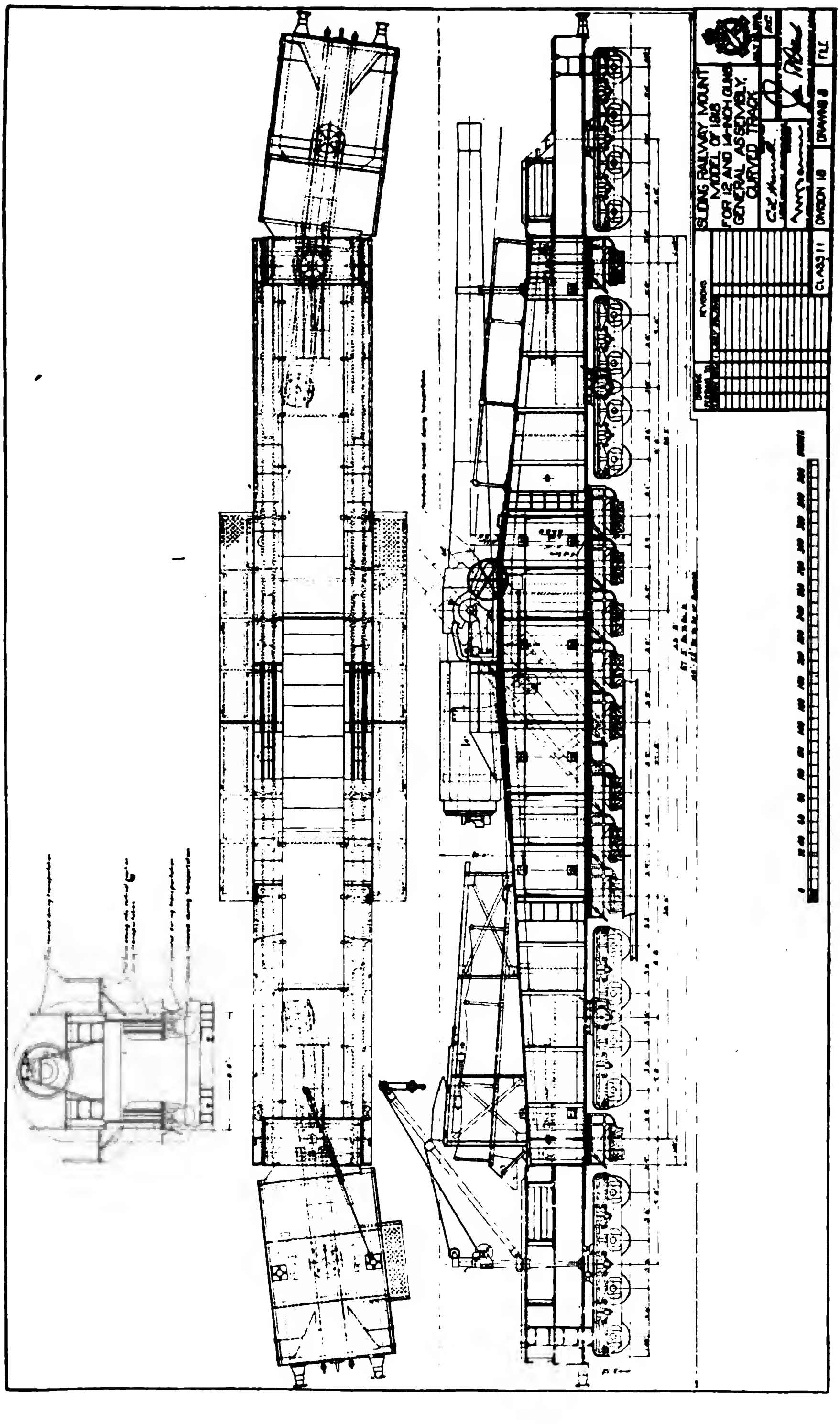


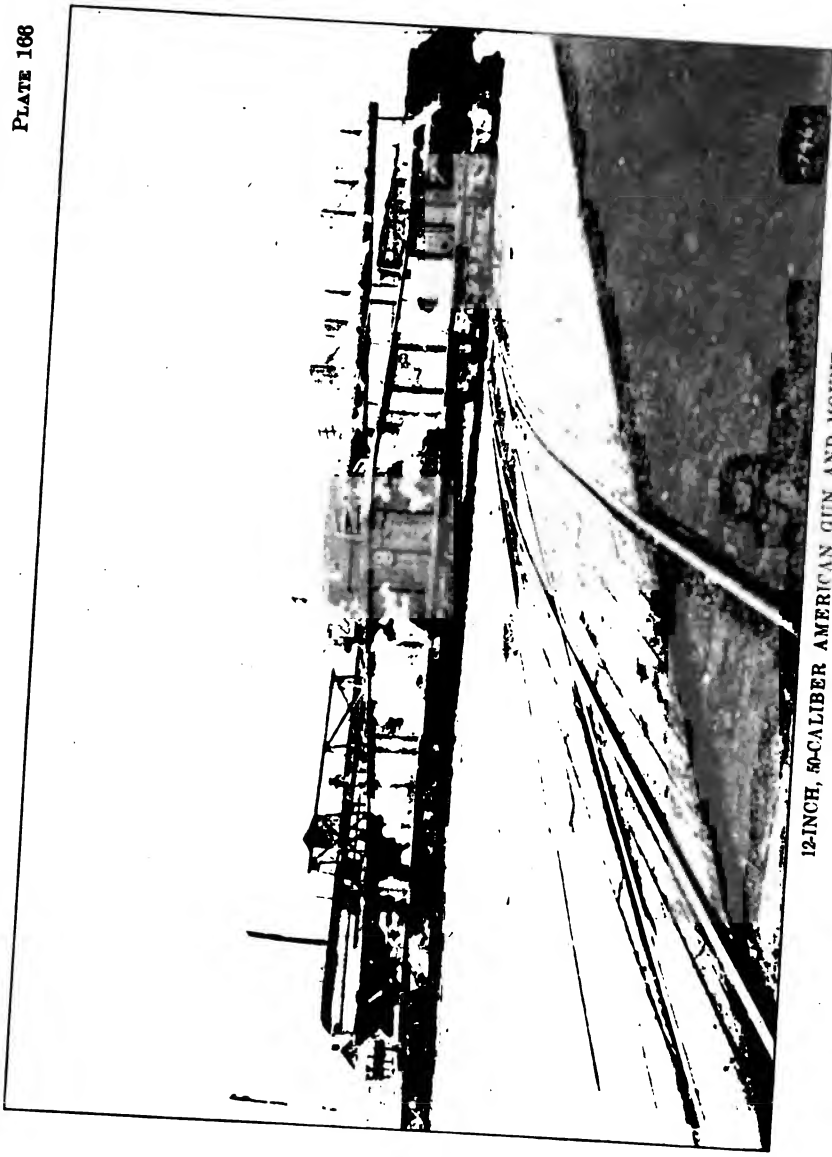
PLATE 104



SLIDING RAILWAY MOUNT
MODEL OF 1918
FOR 12 AND 14-INCH GUNS
GENERAL ASSEMBLY
CURVED TRACK
REVISIONS
CLASS 11
DIVISION 18
DRAWING 8
FILE

COUNTERWEIGHT OF THE 12-INCH. 50-CALIBER AMERICAN GUN.

PLATE 168



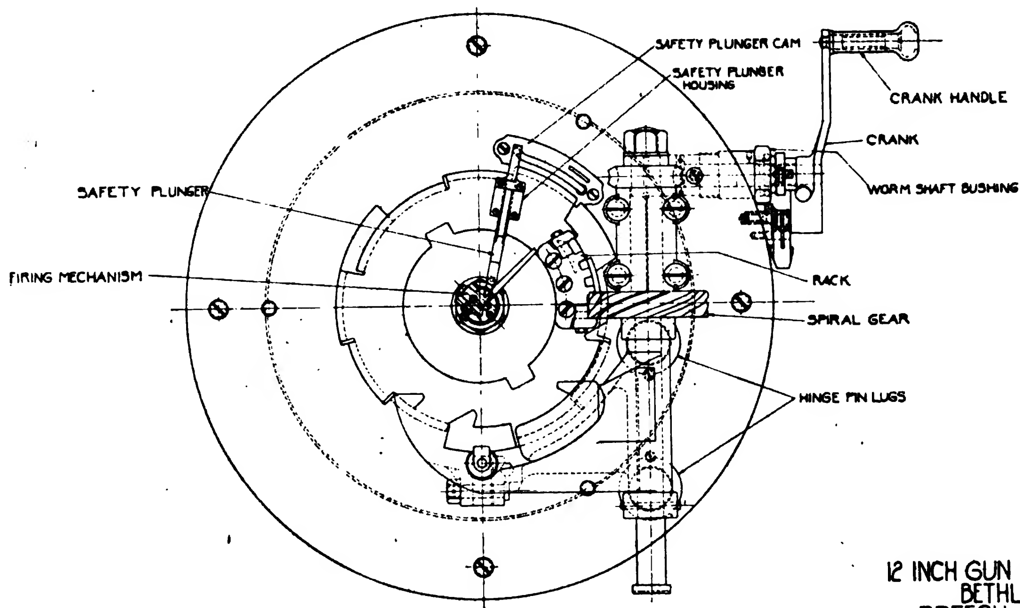
12-INCH, 50-CALIBER AMERICAN GUN AND MOUNT.

12-INCH, 50-CALIBER AMERICAN GUN AND MOUNT.

PLATE 168

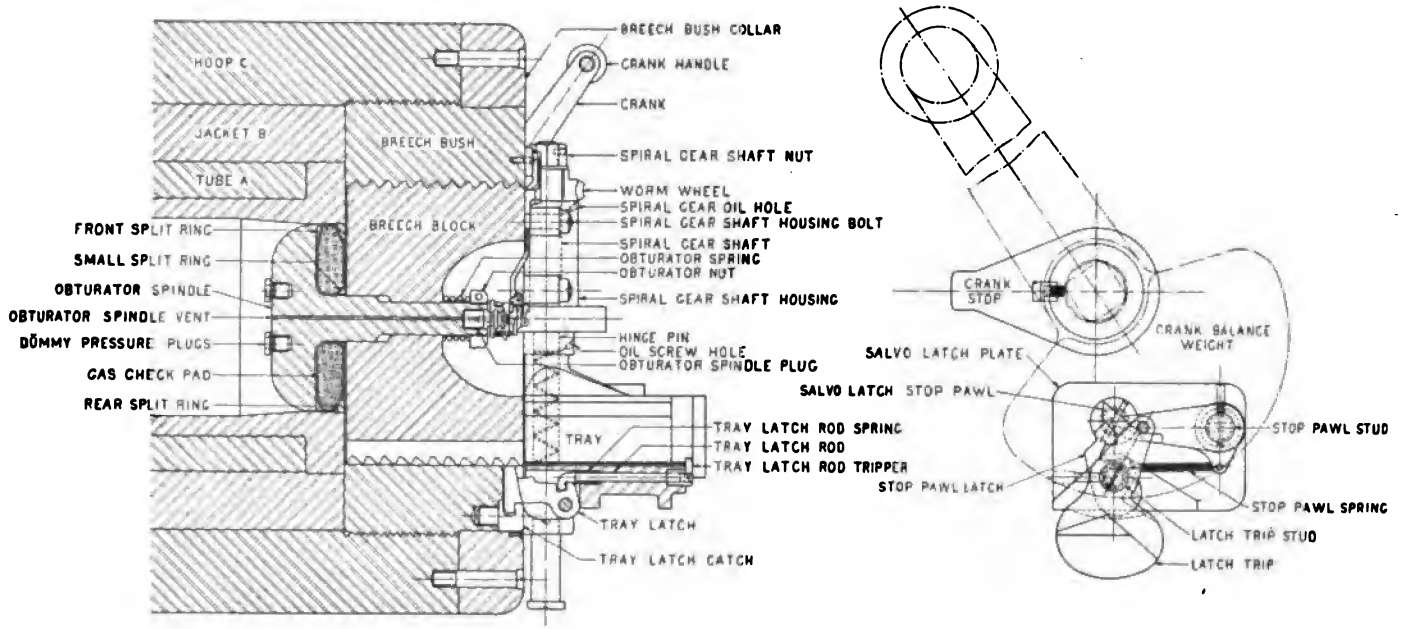
12-INCH, 50-CALIBER AMERICAN GUN.

PLATE 169



12 INCH GUN MODEL OF 1918
BETHLEHEM
BREECH MECHANISM

PLATE 170



12 INCH GUN MODEL OF 1918
(BETHLEHEM)
BREECH MECHANISM

PLATE 171

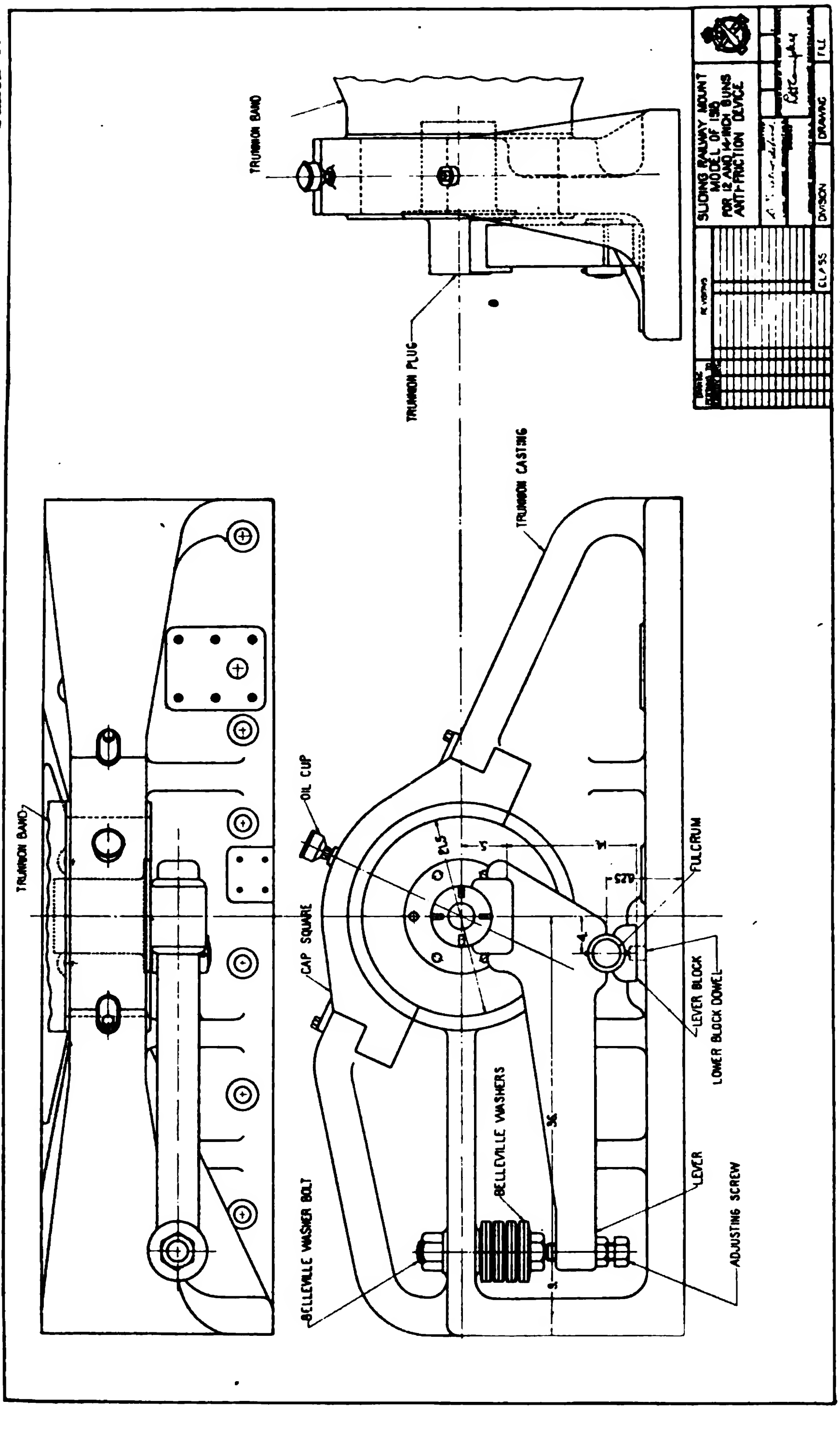

TRUNNION BAND
TRUNNION PLUG
TRUNNION CASTING
TRUNNION BAND
OIL CUP
CAP SQUARE
FULCRUM
LEVER BLOCK
LOWER BLOCK DOWEL
BELLEVILLE WASHERS
BELLEVILLE WASHER BOLT
LEVER
ADJUSTING SCREW
SLIDING RAILWAY MOUNT
MODEL OF 1918
FOR 12 AND 14-INCH GUNS
ANTI-FRICTION DEVICE
DIVISION
DRAWING
FILE
CLASS

PLATE 172

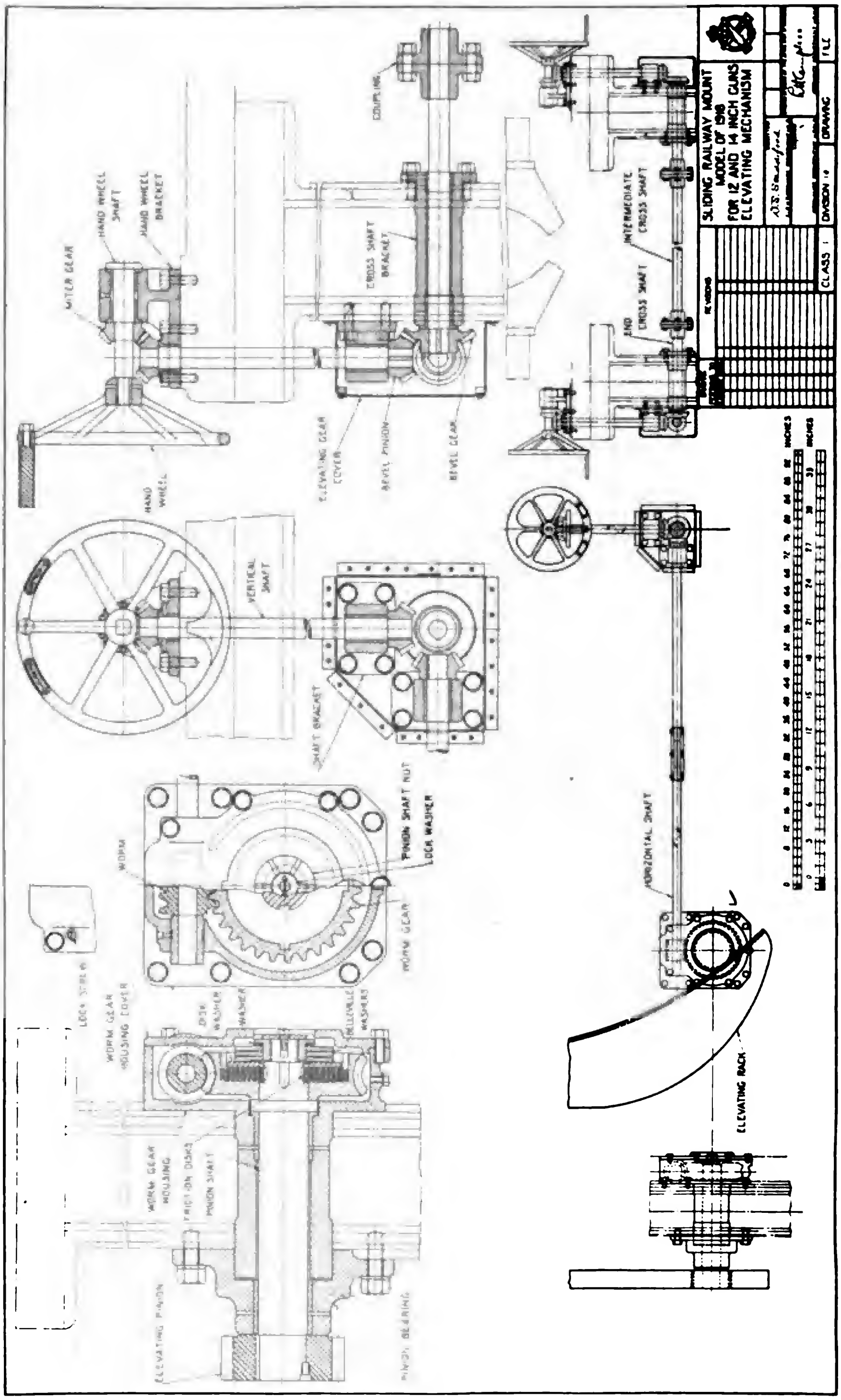

SLIDING RAILWAY MOUNT
MODEL OF 1918
FOR 12 AND 14 INCH GUNS
ELEVATING MECHANISM
REVISIONS
CLASS 1
DIVISION 14
DRAWING
FILE
MITER GEAR
HAND WHEEL SHAFT
HAND WHEEL BRACKET
HAND WHEEL
COUPLING
CROSS SHAFT BRACKET
INTERMEDIATE CROSS SHAFT
END CROSS SHAFT
ELEVATING GEAR COVER
BEVEL PINION
BEVEL GEAR
VERTICAL SHAFT
SHAFT BRACKET
PINION SHAFT NUT
LOCK WASHER
WORM
WORM GEAR
HORIZONTAL SHAFT
ELEVATING RACK
LOCK SCREW
WORM GEAR HOUSING COVER
DISK WASHER
WASHER
BELLEVILLE WASHERS
WORM GEAR HOUSING
FRICTION DISKS
PINION SHAFT
ELEVATING PINION
PINION BEARING
INCHES

PLATE 173

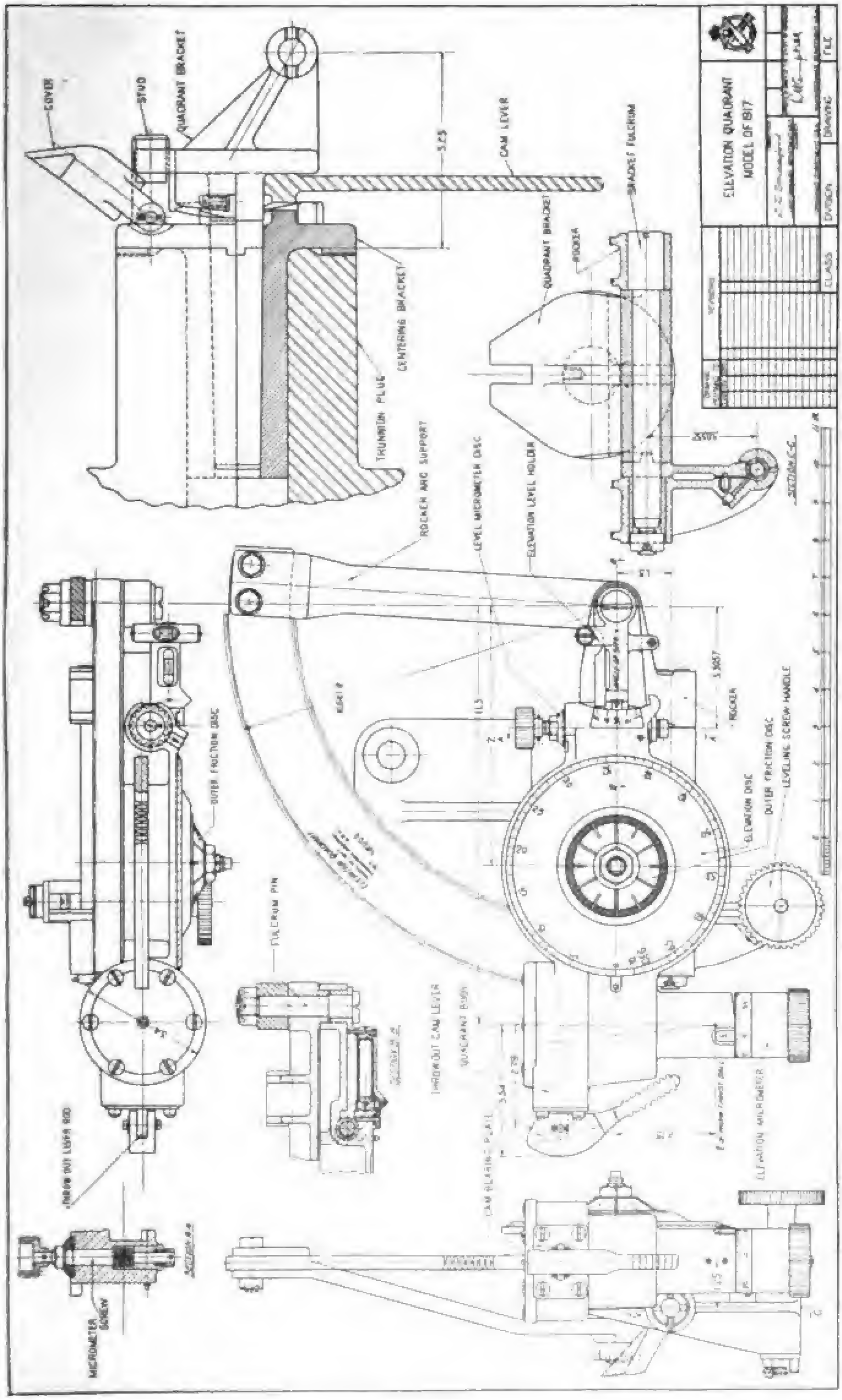
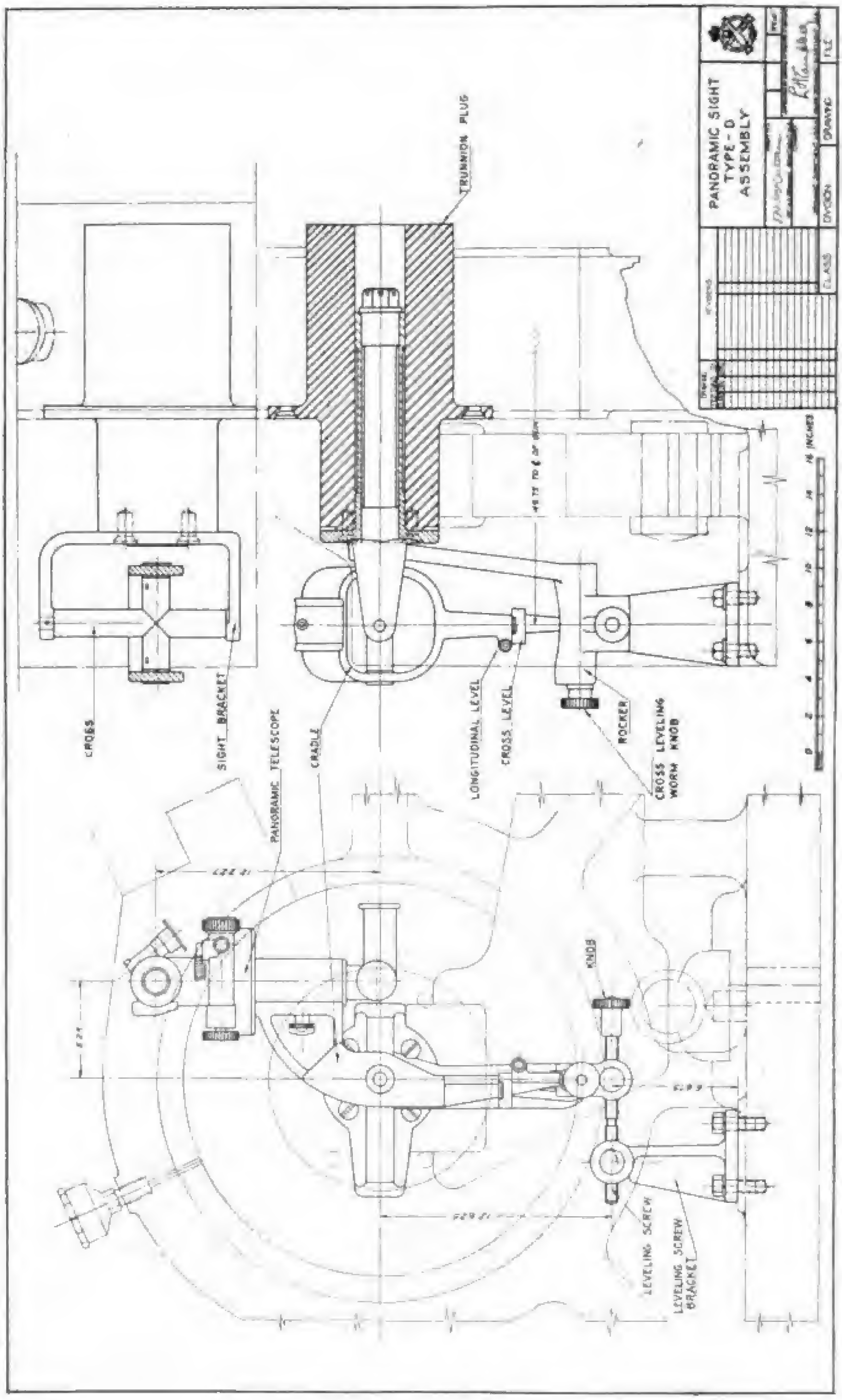
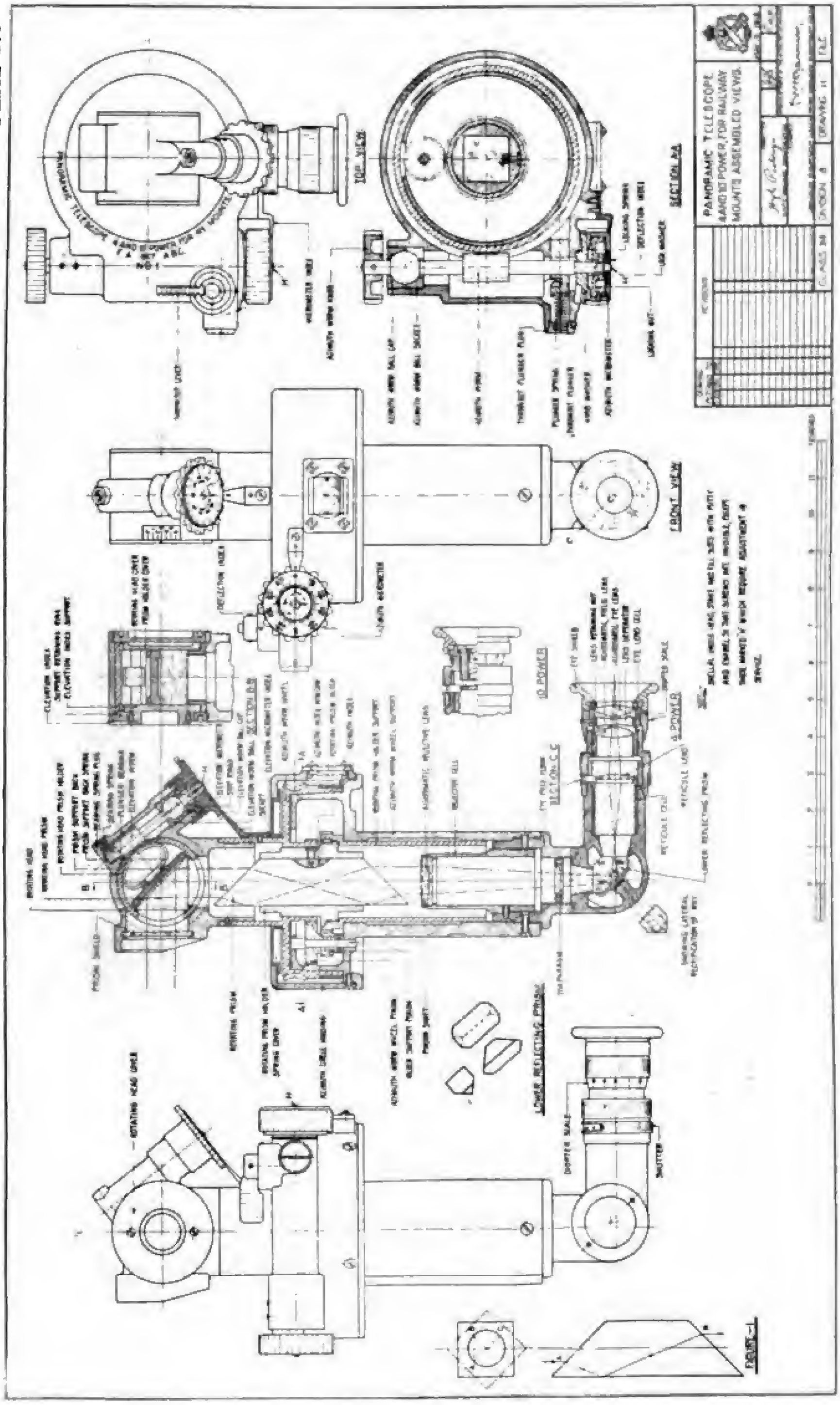

COVER
STUD
QUADRANT BRACKET
CAM LEVER
CENTERING BRACKET
TRUNNION PLUG
ROCKER ARC SUPPORT
LEVEL MICROMETER DISC
ELEVATION LEVEL HOLDER
QUADRANT BRACKET
ROCKER
BRACKET FULCRUM
ELEVATION QUADRANT
MODEL OF 1917
OUTER FRICTION DISC
FULCRUM PIN
THROWOUT CAM LEVER
QUADRANT BODY
CAM BEARING PLATE
ELEVATION MICROMETER
ELEVATION DISC
OUTER FRICTION DISC
LEVELING SCREW HANDLE
THROW OUT LEVER ROD
MICROMETER SCREW
DRAWING
FILE
DIVISION
CLASS

PLATE 174



PANORAMIC SIGHT
TYPE - D
ASSEMBLY
TRUNNION PLUG
CROSS
SIGHT BRACKET
PANORAMIC TELESCOPE
CRADLE
LONGITUDINAL LEVEL
CROSS LEVEL
ROCKER
CROSS LEVELING
WORM KNOB
KNOB
LEVELING SCREW
LEVELING SCREW
BRACKET
INCHES
CLASS
DIVISION
DRAWING
FILE

PLATE 175


PANORAMIC TELESCOPE 4 AND 10 POWER, FOR RAILWAY MOUNTS ASSEMBLED VIEWS.
TOP VIEW
FRONT VIEW
SECTION A-A
SECTION B-B
SECTION C-C
10 POWER
4 POWER
LOWER REFLECTING PRISM
FIGURE-1

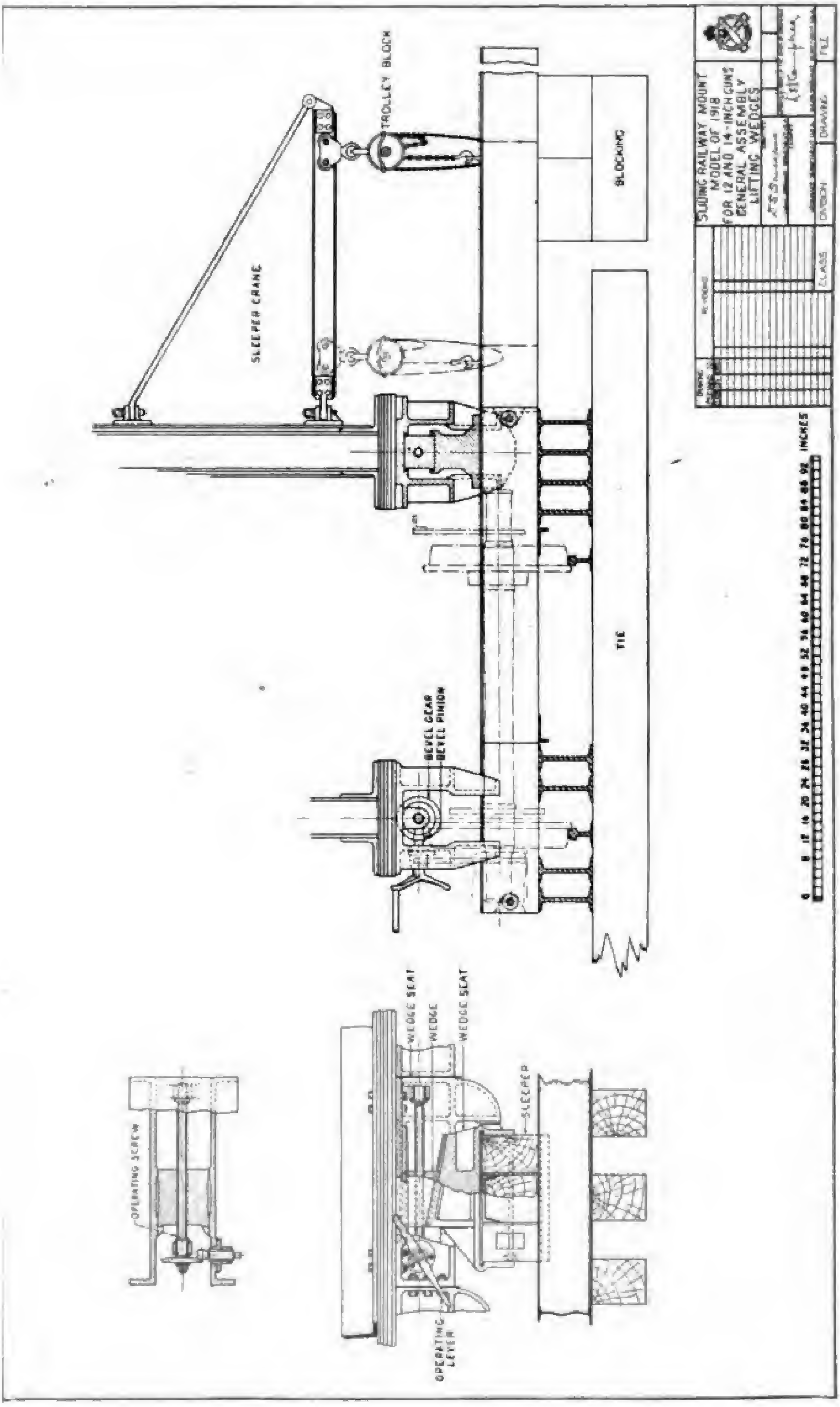

SLIDING RAILWAY MOUNT
MODEL OF 1918
FOR 12 AND 14-INCH GUNS
GENERAL ASSEMBLY
LIFTING WEDGES
TROLLEY BLOCK
SLEEPER CRANE
BLOCKING
TIE
BEVEL GEAR
BEVEL PINION
WEDGE SEAT
WEDGE
WEDGE SEAT
SLEEPER
OPERATING SCREW
OPERATING LEVER
INCHES
CLASS
DIVISION
DRAWING
FILE

Plate 177

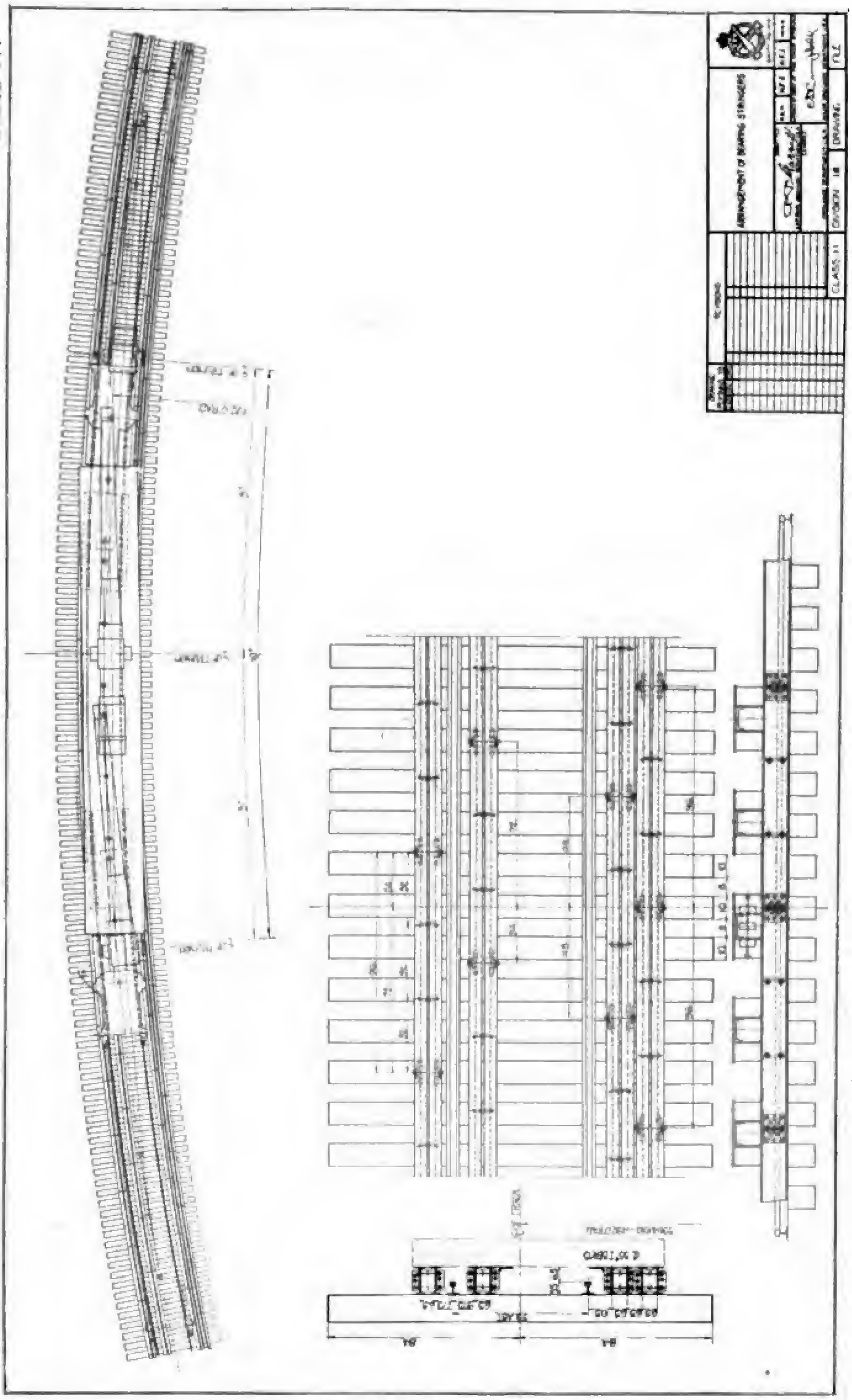


PLATE 178

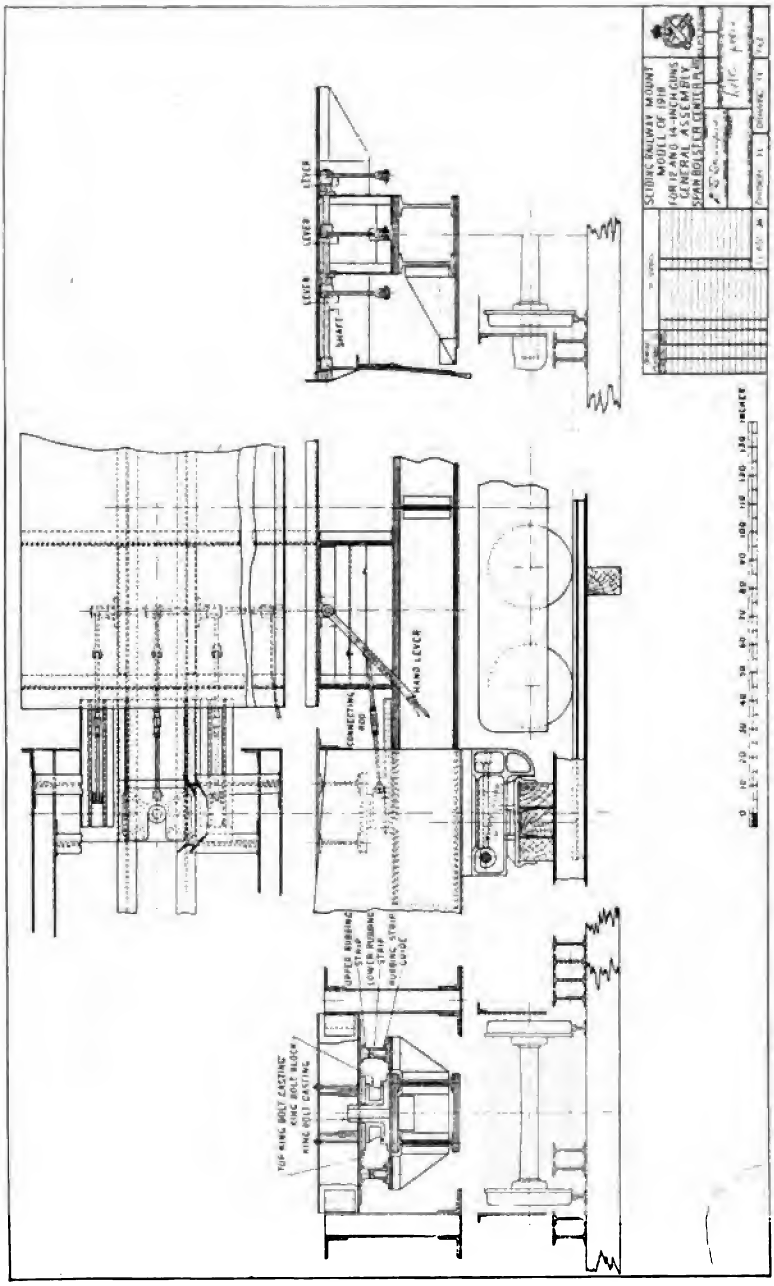

SLIDING RAILWAY MOUNT
MODEL OF 1918
FOR 12 AND 14-INCH GUNS
GENERAL ASSEMBLY
SPAN BOLSTER CENTERING
LEVER
LEVER
LEVER
SHAFT
HAND LEVER
CONNECTING ROD
UPPER RUBBING STRIP
LOWER RUBBING STRIP
RUBBING STRIP GUIDE
TOP KING BOLT CASTING
KING BOLT BLOCK
KING BOLT CASTING

PLATE 179

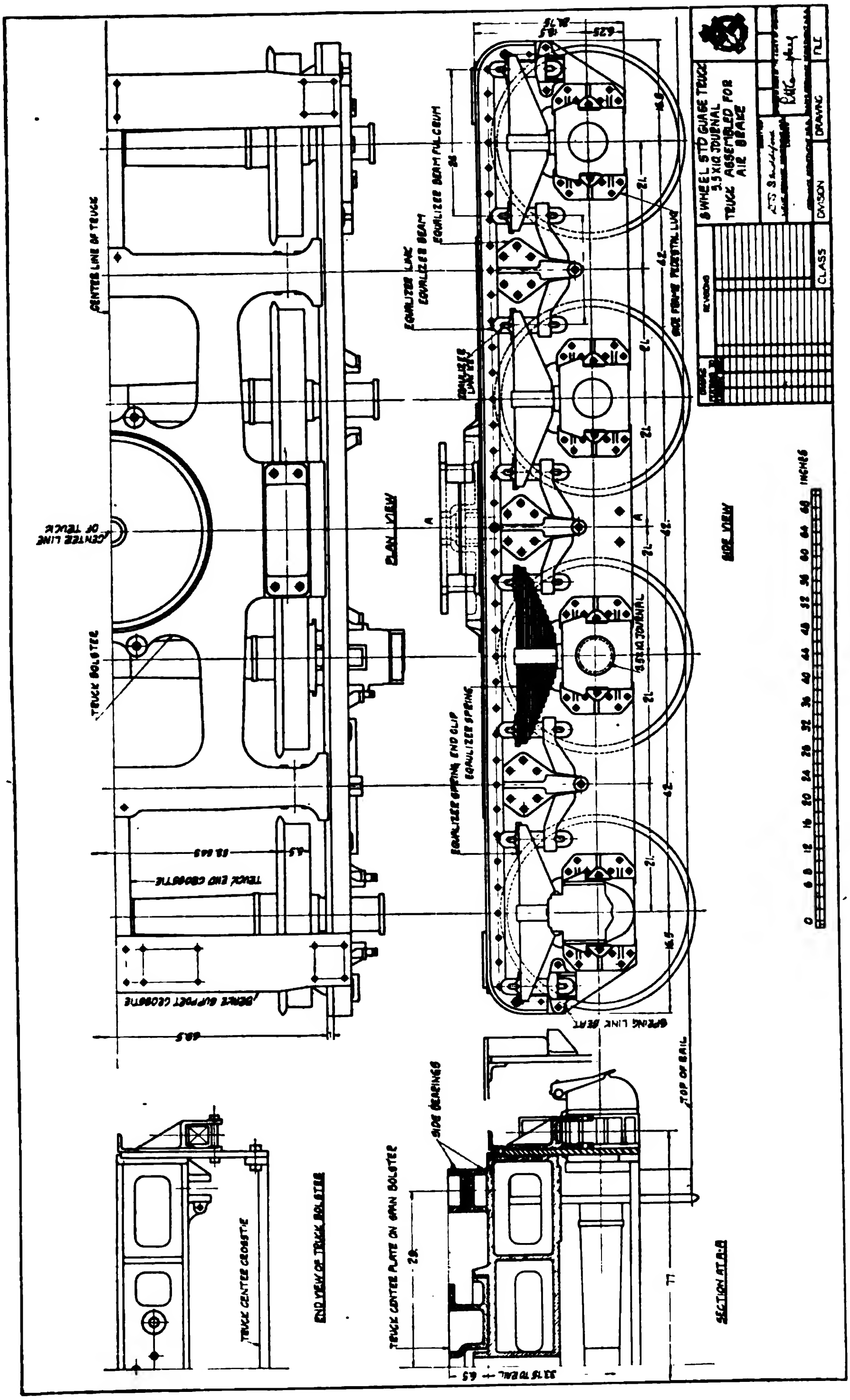

8 WHEEL STD GUAGE TRUCK
3.5 X 10 JOURNAL
TRUCK ASSEMBLED FOR
AIR BRAKE
PLAN VIEW
SIDE VIEW
END VIEW OF TRUCK BOLSTER
SECTION AT A-A
CENTER LINE OF TRUCK
TRUCK BOLSTER
TRUCK END CROSSTIE
TRUCK CENTER CROSSTIE
SIDE BEARINGS
TOP OF RAIL
EQUALIZER BEAM
EQUALIZER LINK
EQUALIZER SPRING
SIDE FRAME PEDESTAL LINE
SPRING LINK SEAT
CLASS
DIVISION
DRAWING
INCHES

PLATE 180

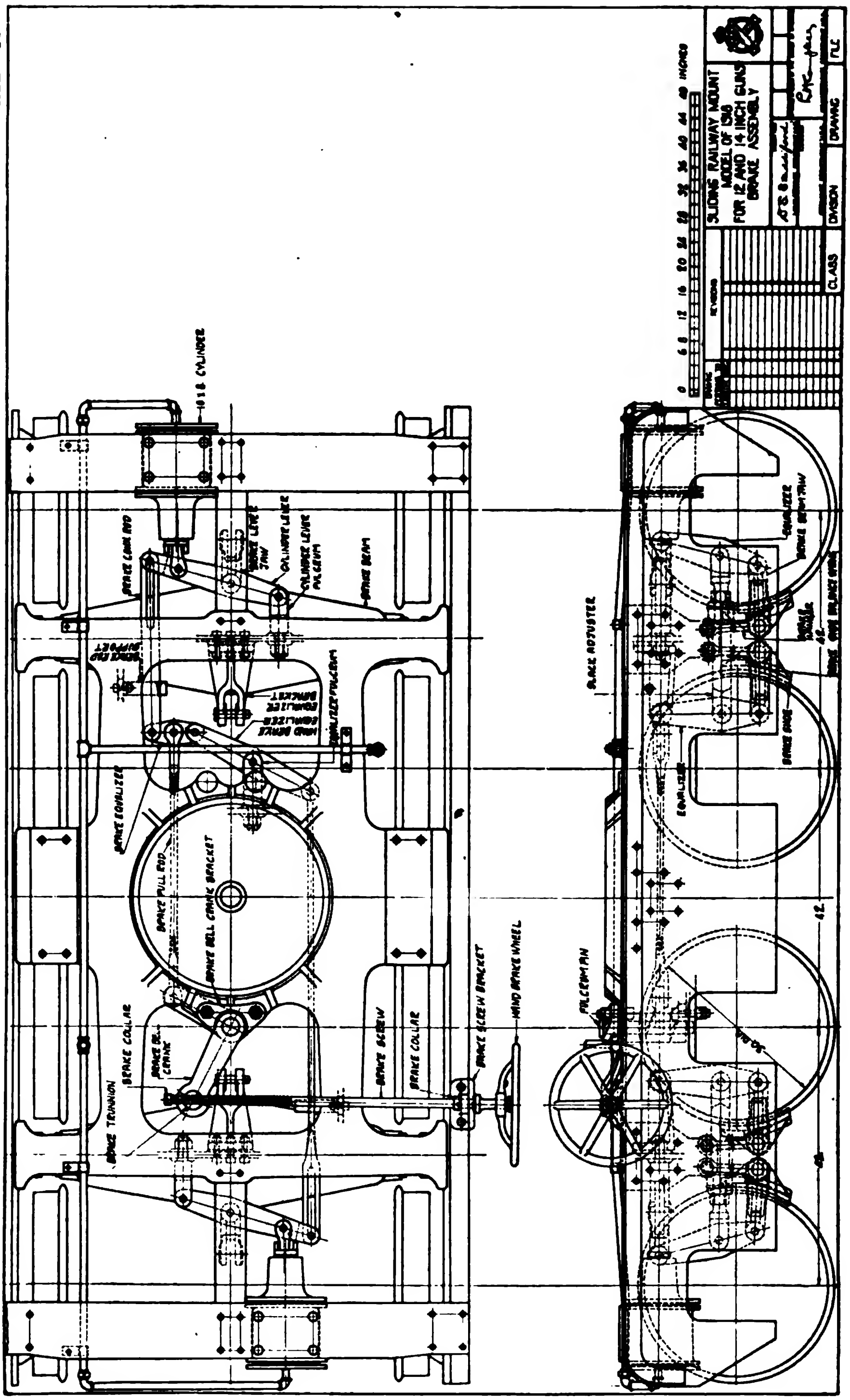
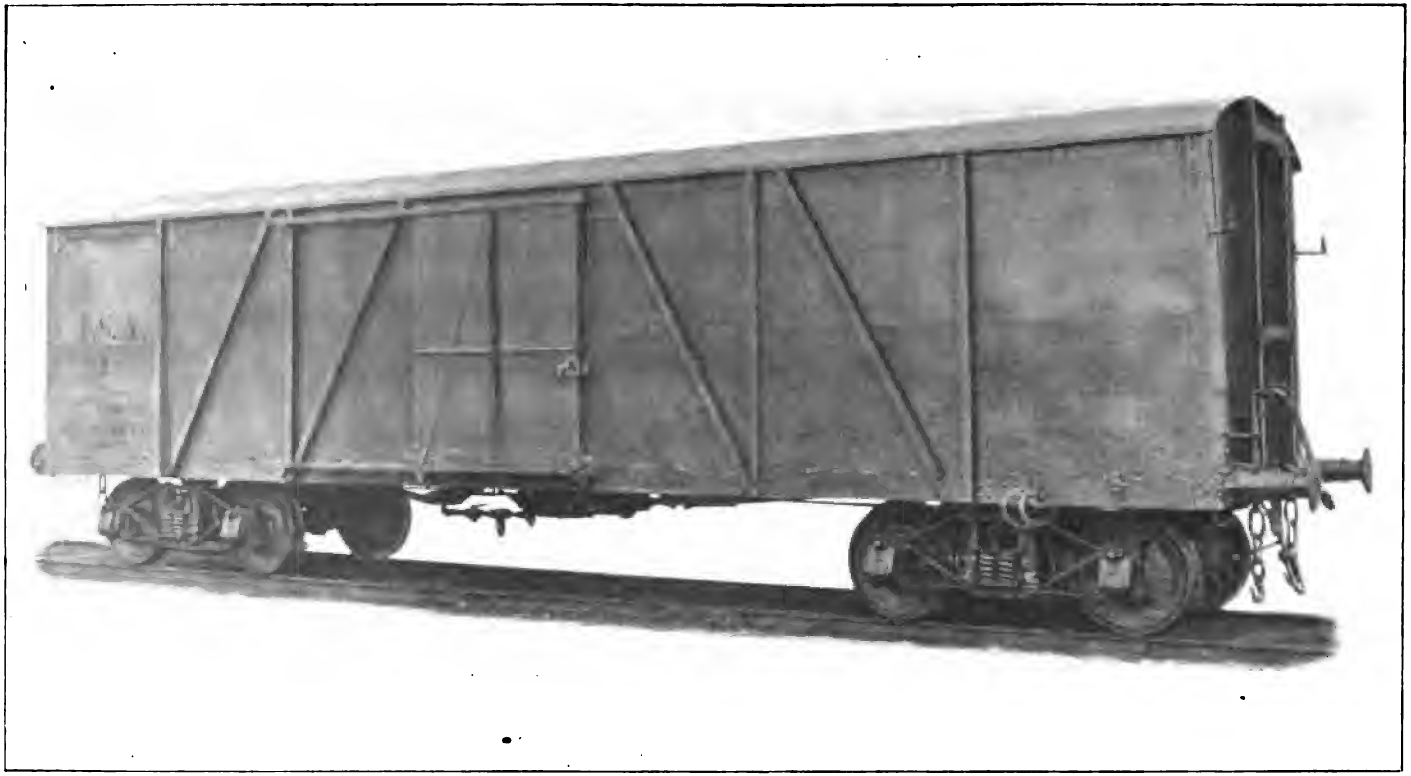

SLIDING RAILWAY MOUNT
MODEL OF 1918
FOR 12 AND 14 INCH GUNS
BRAKE ASSEMBLY
CLASS
DIVISION
DRAWING
FILE

PLATE 181



STANDARD AMMUNITION CAR FOR USE WITH ALL AMERICAN RAILWAY MOUNTS.

PLATE 182

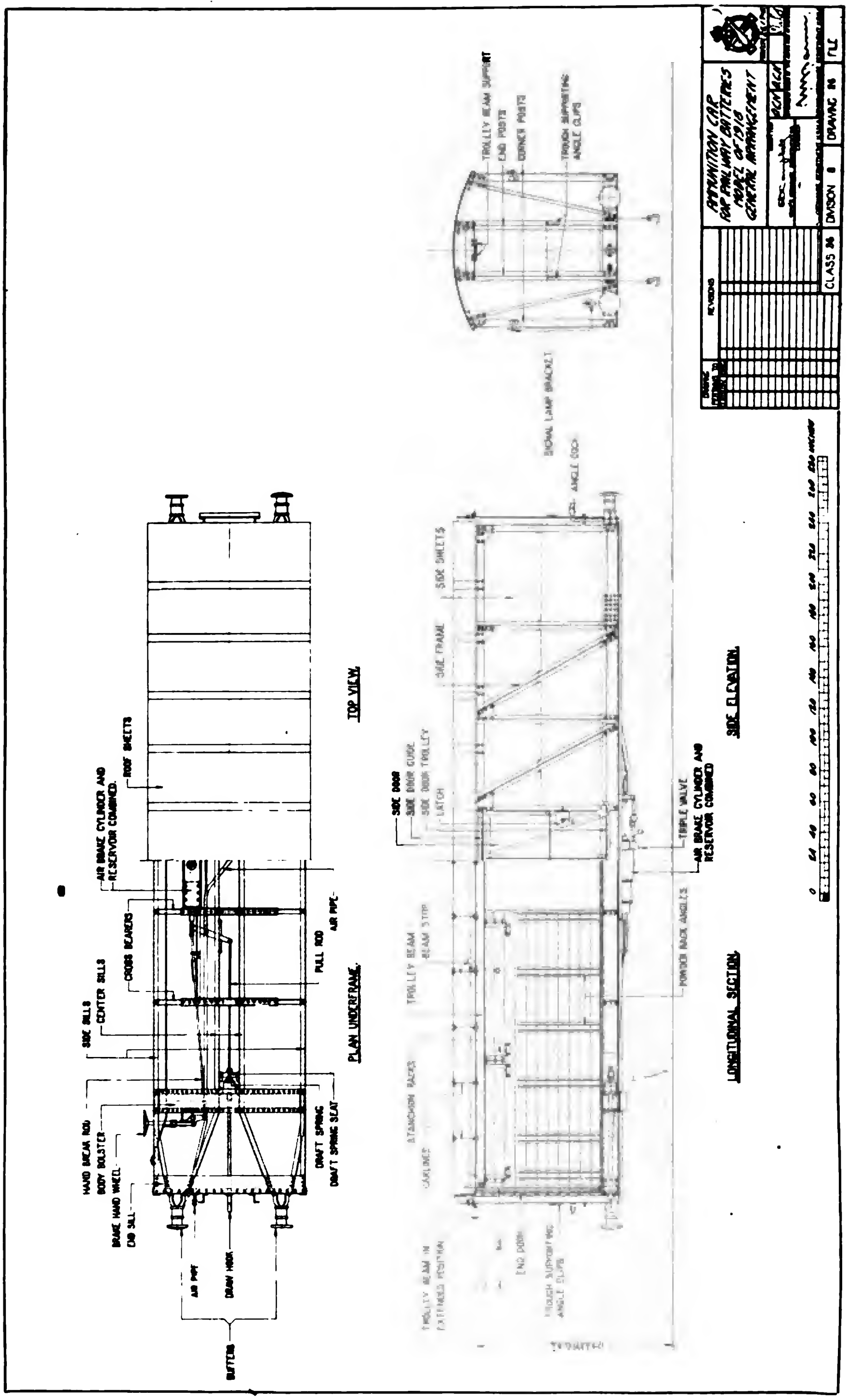
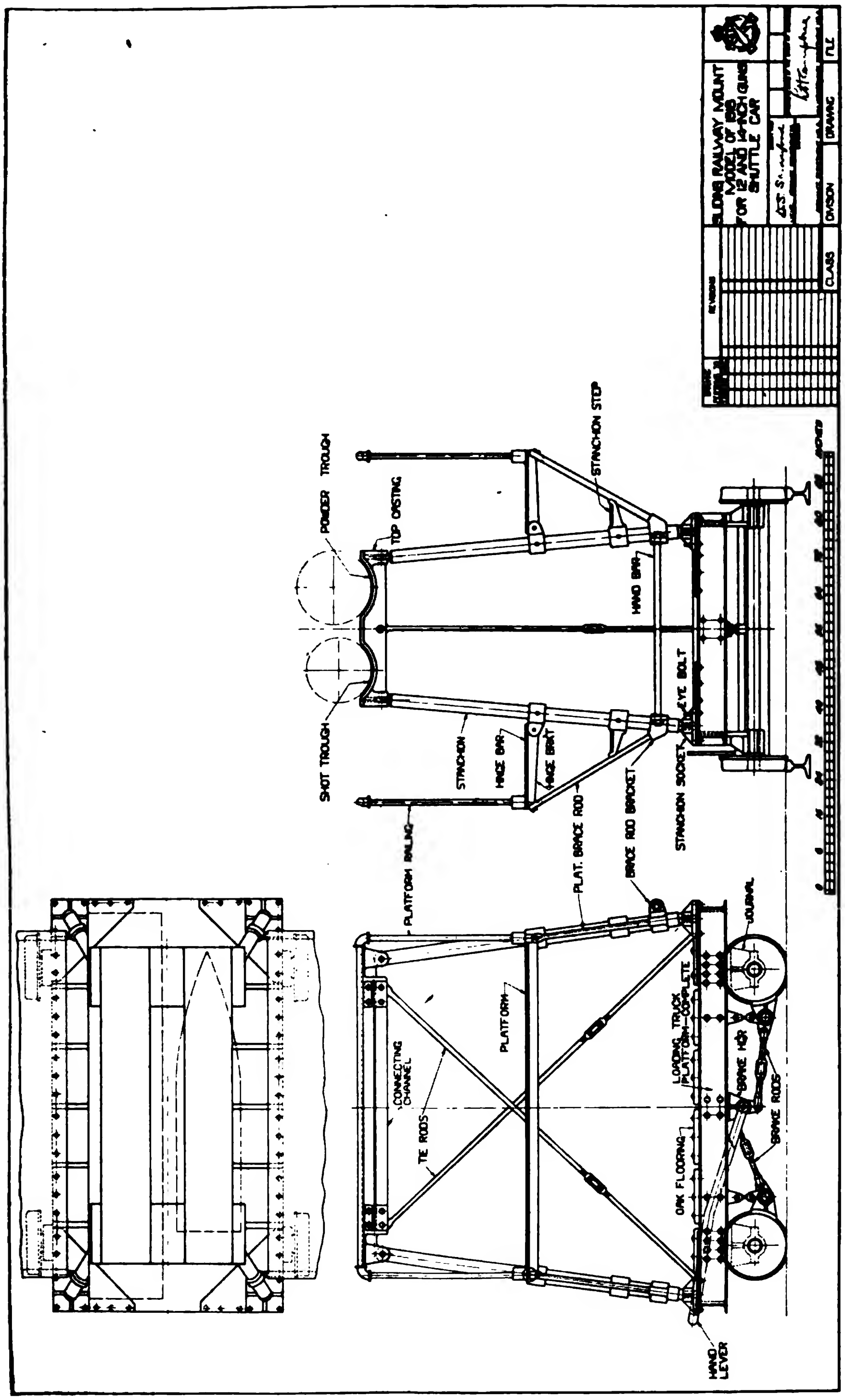
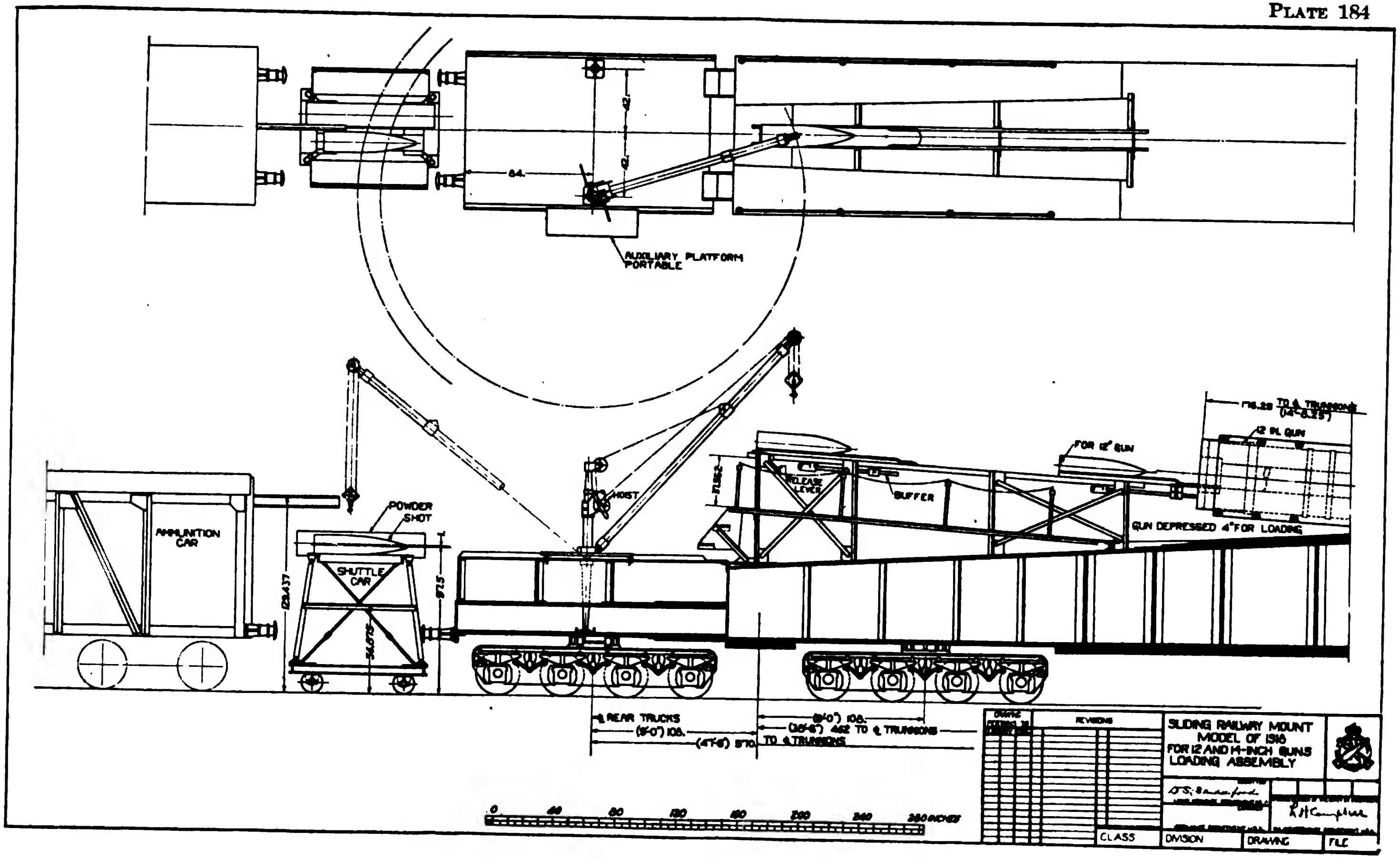

TOP VIEW
ROOF SHEETS
PLAN UNDERFRAME
AIR BRAKE CYLINDER AND RESERVOIR COMBINED
CROSS BEARERS
CENTER SILLS
SIDE SILLS
HAND BREAK ROD
BODY BOLSTER
BRAKE HAND WHEEL
END SILL
AIR PIPE
DRAW HOOK
BUFFERS
PULL ROD
AIR PIPE
DRAFT SPRING
DRAFT SPRING SEAT
LONGITUDINAL SECTION
SIDE DOOR
SIDE DOOR GUIDE
SIDE DOOR TROLLEY
LATCH
TROLLEY BEAM
BEAM STOP
STANCHION RACKS
CARLINES
TROLLEY BEAM IN EXTENDED POSITION
END DOOR
TROUGH SUPPORTING ANGLE CLIPS
POWDER RACK ANGLES
TRIPLE VALVE
AIR BRAKE CYLINDER AND RESERVOIR COMBINED
SIDE ELEVATION
SIDE FRAME
SIDE SHEETS
SIGNAL LAMP BRACKET
ANGLE COCK
TROLLEY BEAM SUPPORT
END POSTS
CORNER POSTS
TROUGH SUPPORTING ANGLE CLIPS
REVISIONS
AMMUNITION CAR FOR RAILWAY BATTERIES MODEL OF 1918 GENERAL ARRANGEMENT
CLASS 36
DIVISION 8
DRAWING 86

PLATE 183



SLIDING RAILWAY MOUNT MODEL OF 1918 FOR 12 AND 14-INCH GUNS SHUTTLE CAR
REVISIONS
CLASS
DIVISION
DRAWING
FILE
POWDER TROUGH
TOP CASTING
STANCHION STEP
HAND BAR
EYE BOLT
SHOT TROUGH
STANCHION
HINGE BAR
HINGE BRKT
PLATFORM RAILING
PLAT. BRACE ROD
BRACE ROD BRACKET
STANCHION SOCKET
INCHES
JOURNAL
PLATFORM
CONNECTING CHANNEL
TIE RODS
LOADING TRUCK PLATFORM COMPLETE
BRAKE HGR
BRAKE RODS
OAK FLOORING
HAND LEVER

PLATE 184


AUXILIARY PLATFORM PORTABLE
HOIST
POWDER
SHOT
SHUTTLE CAR
AMMUNITION CAR
RELEASE LEVER
BUFFER
FOR 12" GUN
12 IN. GUN
GUN DEPRESSED 4° FOR LOADING
REAR TRUCKS
TO TRUNNIONS
SLIDING RAILWAY MOUNT
MODEL OF 1918
FOR 12 AND 14-INCH GUNS
LOADING ASSEMBLY
REVISIONS
CLASS
DIVISION
DRAWING
FILE
280 INCHES

8.—AMERICAN 12-INCH HOWITZER ON RAILWAY MOUNT. (21)

193. This entire design was made up in response to a request from the Expeditionary Forces in France for a long 12-inch mortar with a range of 20,000 yards, mounted on a carriage that would be emplaced in a manner similar to the 8-inch gun and 12-inch mortar carriages, and from which the mortar could be fired over either end, and with a traverse of from 20 to 30 degrees on each side of the center. Accordingly a cannon of 20 calibers length and capable of being operated at a pressure that would give sufficient muzzle velocity to attain the desired 20,000 yards range was designed and was mounted on a carriage similar to the carriage used for the 8-inch gun and 12-inch mortar. The difference between the details of this and the previous designs will be pointed out later. It is probable that this represents the limit of the ability of the designer to combine in one unit a gun of so great an elevation as 65 degrees and a traverse of 360 degrees from a carriage equipped with self-contained emplacing facilities which enable the mount to be emplaced for action on any existing standard track in less than one hour. From the standpoint of these characteristics of great muzzle energy, high elevation, wide traverse, and rapid emplacement it is felt that this is among the most valuable, if it is not actually the most valuable, mount now in the possession of the American Army. Recent investigations indicate that with the addition of a new cradle it will be possible to operate an 8-inch, 50-caliber gun from the same carriage. The mount and its details are illustrated on plates 185 to 215 and 125.

194. Gun.—The gun for this carriage is a 12-inch, 20-caliber howitzer, model 1919, of built-up design. This howitzer has, at various times, been termed a "long mortar" and a "howitzer"; in this treatment, however, it will be known as a howitzer. It is fitted with a breechblock of the interrupted thread design, which is fitted with a mechanical firing mechanism. It has 108 grooves and the rifling twists to the right, the pitch increasing from one turn in 40 calibers to one turn in 20 calibers. Its probable life is 500 rounds.

195. Recoil Mechanism.—The recoil mechanism, plates 196 and 197, comprises two hydraulic recoil cylinders fitted into the cradle on either side of the center at the bottom, and a pneumatic recuperator attached to the top of the cradle in the center. The maximum length of recoil is 37.5 inches. The design of the recoil cylinders, plate 198, is not unlike that of the cylinders used on previously designed mounts. The design of the recuperator, plate 199, is essentially the same as the recuperator described in detail under the 12-inch mortar. An air bottle is carried on the left side of the carriage and is permanently connected by small tubing with the rear of the recuperator cylinders, plate 197. Gauges for measuring

the initial air and liquid pressures are mounted on the left side of the cradle. A liquid pump, plate 200, for maintaining the floating piston in the recuperator in its proper relative position is likewise mounted on the left side of the cradle between the two gauges.

196. ELEVATING MECHANISM.—The elevating mechanism comprises a circular rack bolted to the right side of the cradle, a pinion meshing with this, and a train of spur gears leading to the single handwheel mounted on the right side of the carriage, plate 201. As a substitute for the usual slip friction device, this mechanism includes a brake on the handwheel of a design similar to that of the service brake of an automobile. The drum is a part of the handwheel, plate 201, and the brake grips it tightly except when the foot pedal, plate 202, is pressed down. This elevating mechanism comprising spur gears only, follows the design of the elevating mechanism of the 16-inch howitzer mechanism which was found particularly efficient. An antifriction device, plate 203, is mounted with each trunnion to reduce the effort required in elevating and depressing the gun. The principle of the operation of this device is the same as that of other devices already described, although it differs in the details of its design. The elevation quadrant used with this mount is the special elevation quadrant, model 1917, plate 173, designed for use with railway mounts.

197. TRAVERSING MECHANISM.—The traversing mechanism comprises a circular rack bolted to the inside of the base ring, plate 196, a pinion meshing with this, and a vertical shaft leading to the worm wheel, worm and hand wheel, plate 204, mounted on the left side of the carriage. The ratio of the gearing is one turn of the handwheel for 1.028 degrees of traverse. The panoramic sight used with this mount is identical with that shown on plates 174 and 175.

198. GUN CARRIAGE.—The top of the gun carriage comprises a cradle of grid-iron design, plate 197, a top carriage body made up of two cast steel side frames and light front and rear transoms connecting these, plates 186, 187, and 196, a structural steel working platform carrying the ammunition table and crane, plates 196, 205, and 206, all of which are carried on a cast steel racer, plate 196. Attention is invited to the differences in the details of the design of this racer, plate 196, and the racers for the 8-inch gun and 12-inch mortar, plates 33 and 38.

199. RAILWAY CAR BODY.—The railway car body, plates 196 and 207, is in its details quite unlike that of the 8-inch gun and 12-inch mortar. The 8-inch gun and 12-inch mortar car bodies are built entirely of structural steel. Even with the best work that it was possible to secure on these mounts, the bed on which the base ring rests was invariably so buckled as to require an undue amount of lining up, and even after being properly lined, was not satisfactorily rigid. In this design the car body is composed of three parts,

the two ends of structural steel and the center a steel casting. It will be noted that the casting has sufficient drop at the center to permit it to rest on the firing beams, sleepers being used only at the ends. It is likewise satisfactorily rigid, and eliminates entirely the necessity for lining up already mentioned for other mounts. The structural steel ends are bolted to the center section. It is possible that the car body of this design can not be so quickly manufactured as if it were entirely of structural steel, but it is believed that the advantages in having so rigid a base outweigh the disadvantages in time of construction. Attention is called to the fact that this cast-steel section is open in the center permitting the gun to recoil practically to the level of the ties. Comparison of this mount with the 8-inch railway mount will show that this principle of permitting the gun to recoil through the base ring of the top carriage and center ring of the car body has resulted in decreasing considerably the distance from the center line of the trunnions to the top of the rails. This, of course, decreases the distances between the trunnions and the point at which the outriggers are attached and when firing at wide angles to the track the line of recoil is more nearly in line with the outriggers and the mount is much more stable. The draft gear, plate 208, is so designed as to reduce the severe buffing shock when the mount is being made up into a train or when it is traveling.

200. Anchorage.—The system of anchorage is essentially like that of the 8-inch gun and 12-inch mortar mounts. The outriggers, plates 186, 187, and 209, are attached to the car body by means of universal joints giving a much wider range of action than the ball joints used on the other mounts. Tension rods permanently attached to the car are provided for each of the struts to counteract certain tendencies of the car to jump when gun is fired at low elevations. In emplacing the mount for action, built-up beams are placed across the rails, plate 210, and the car is raised by means of four screw jacks, plate 211. When the carriage has been raised a sufficient amount, the built-up steel firing beams are placed on the ties outside the rails with two sleepers across each end. The mount is then lowered until it rests on these sleepers and beams. The cast-steel center section of the car body rests directly on these structural-steel firing beams. In transit the firing beams, sleepers, cast bearing plates and floats are arranged on the mount as shown on plate 191.

201. Trucks.—This mount is provided with two 6-wheel trucks with 28-inch steel wheels and 5.5 by 10-inch outside journals, plate 212. The trucks are equipped with both hand and air brakes, plates 213 and 214.

202. Ammunition Supply System.—Ammunition tables and trays are built into each end of the car body, plate 186. A loading stand is built into the working platform in the center at the rear, plate 215.

and projectiles are transferred to it from the table on the car body by hand operated jib cranes, plates 215 and 216. Experience on railway artillery in France resulted in the specification that the ammunition supply system for this mount be so designed as to permit of operation of the gun from either end of the car with equal facility. The gun can be traversed through 360 degrees and no matter how it may be run in on its emplacement, it can be operated in any direction. As long as the gun operates within the scope of either end of the car, ammunition can be supplied directly from the ammunition car to the tray at the end and from the tray by means of the cranes to the ammunition table on the top carriage. When the gun is operated at wide angles to the track, after each third shot the gun carriage must be traversed back within reach of the shell tray on the car. This is not a disadvantage, however, since the carriage can be traversed easily and quickly and no time will be lost. The tables on either end of the car, plates 189 and 190, will hold seven projectiles each, and the ammunition stand on the working platform will hold three projectiles.

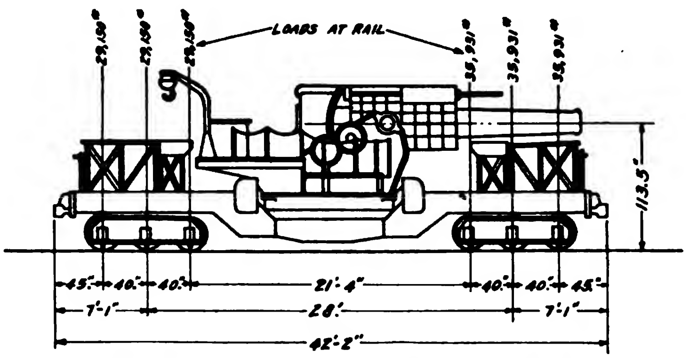
203. MAINTENANCE.—It is not believed that any difficulty will be experienced in the service of a mount of this design. Quite probably the attention required on the recoil cylinders and the recuperator, together with the minor service to keep the elevating and traversing mechanisms in good shape will constitute the bulk of the maintenance.

204. MERITS.—For a gun of this caliber and length, this is the best designed in all of its details that the writer has seen in any army. Its recoil mechanism is unusually fine, the elevating and traversing mechanisms are rapid and efficient; the car-body design, involving the use of a centrally cast-steel section is excellent; the details of the anchorage system are very good and the ammunition supply system equally good. When handled with care and by experienced artillerymen, this gun will probably render more efficient service than any other railway mount possessed by the American Army.

205. DEMERITS.—There seems to be no ground for criticism of any part of the mount except possibly the elaborate design of the cradle. The objection that is raised to this design is the time required to make patterns, the time required to make the castings, and the difficulties involved in making perfect castings. Under peacetime manufacturing conditions such a design may not be due for much criticism. Under stress of war-time conditions, however, it can not be manufactured with satisfactory speed, and is likely to tie up shop facilities for an undue length of time. Cradles of foreign design have been observed which are practically smooth cylinders. It is quite true that such cylinders are not as rigid as the design under discussion, but they have been used with 15-inch 45-caliber guns, and have not developed serious faults.

PLATE 185

12 IN. HOWITZER RAILWAY MOUNT-MODEL 1919
TOTAL WEIGHT 195,243 LBS.



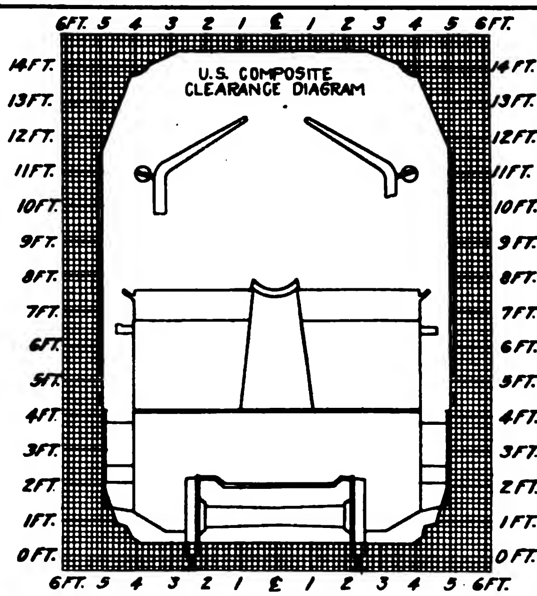
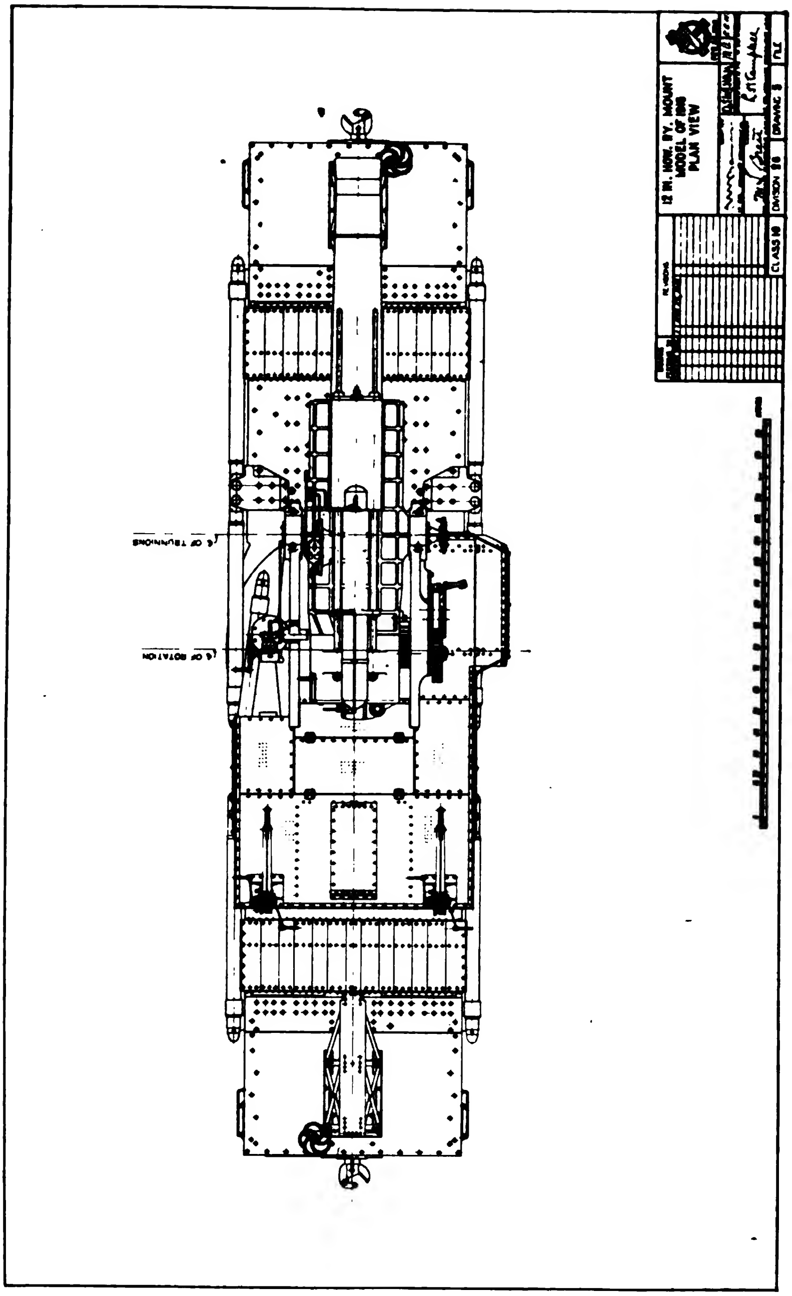


PLATE 183



12 IN. HOW. RY. MOUNT
PLAN VIEW
℄ OF TRUNNIONS
℄ OF ROTATION
CLASS
DIVISION
DRAWING
FILE

PLATE 189

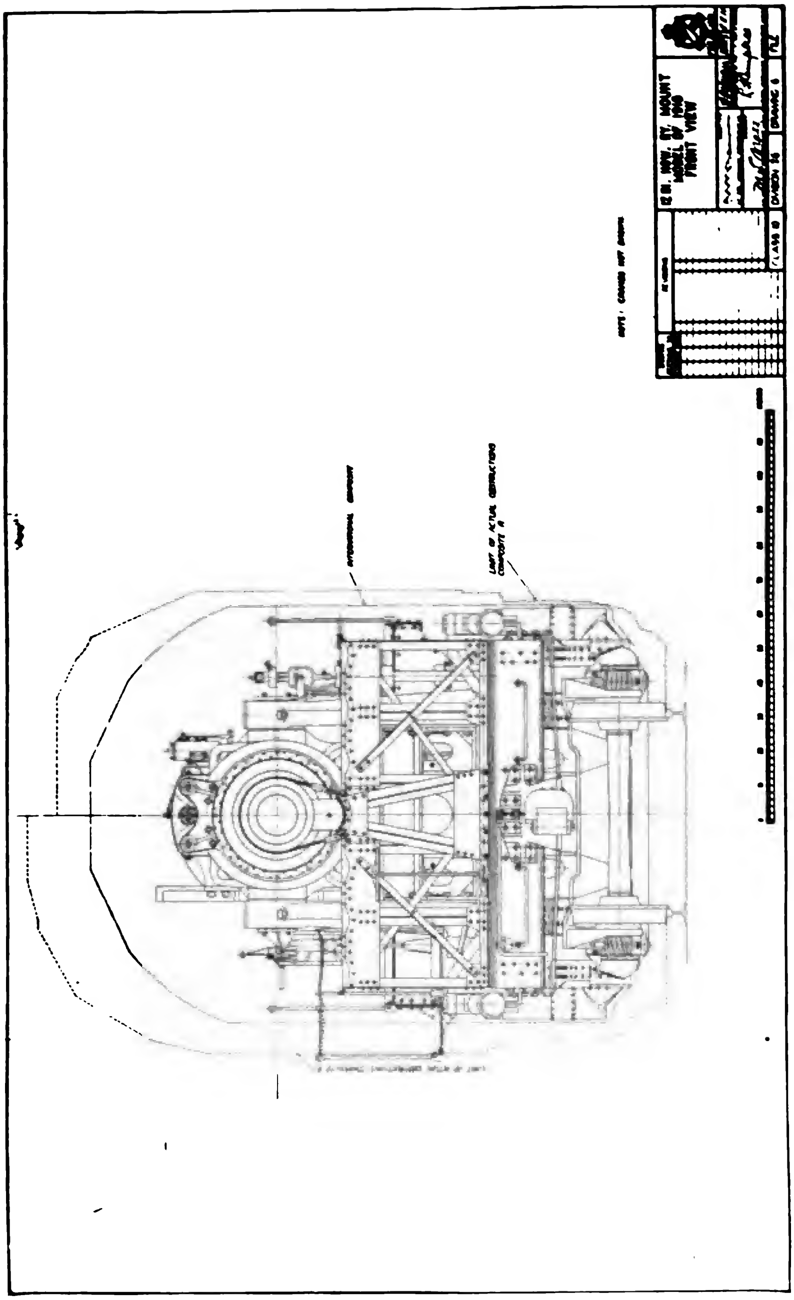


PLATE 190

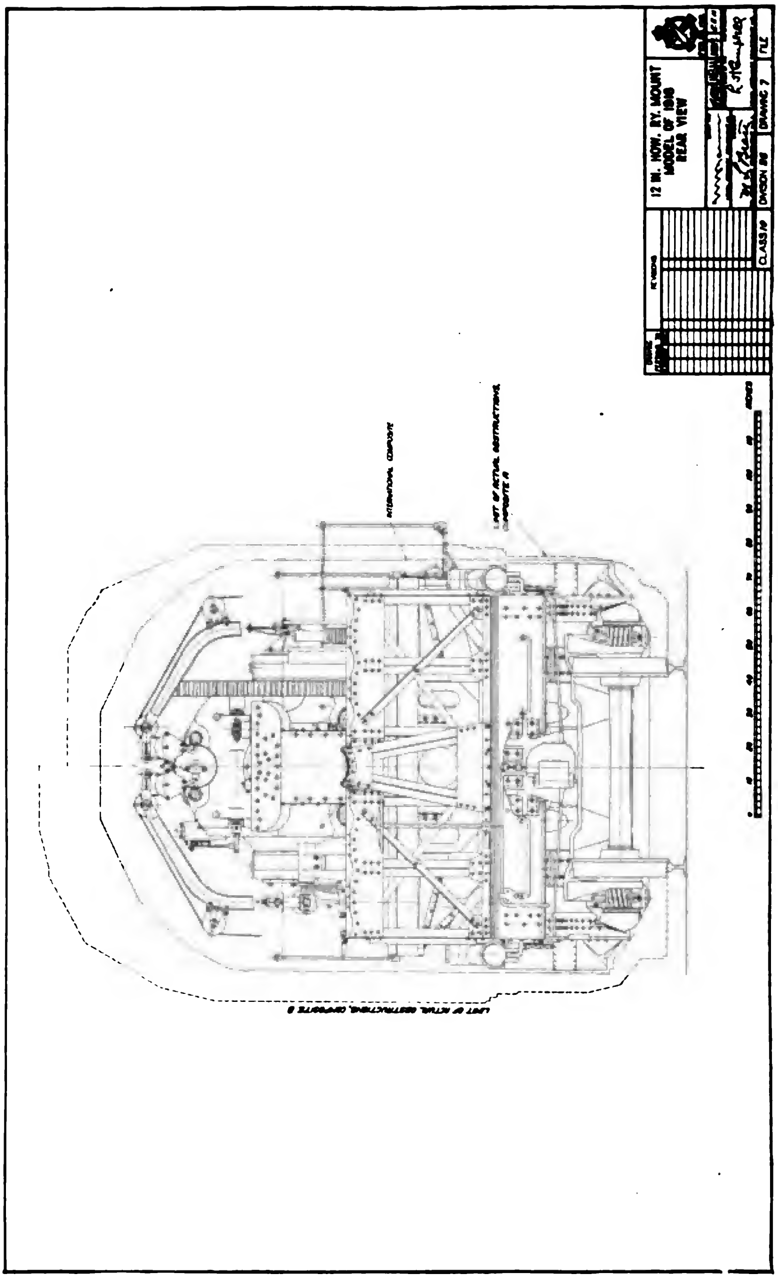


PLATE 191

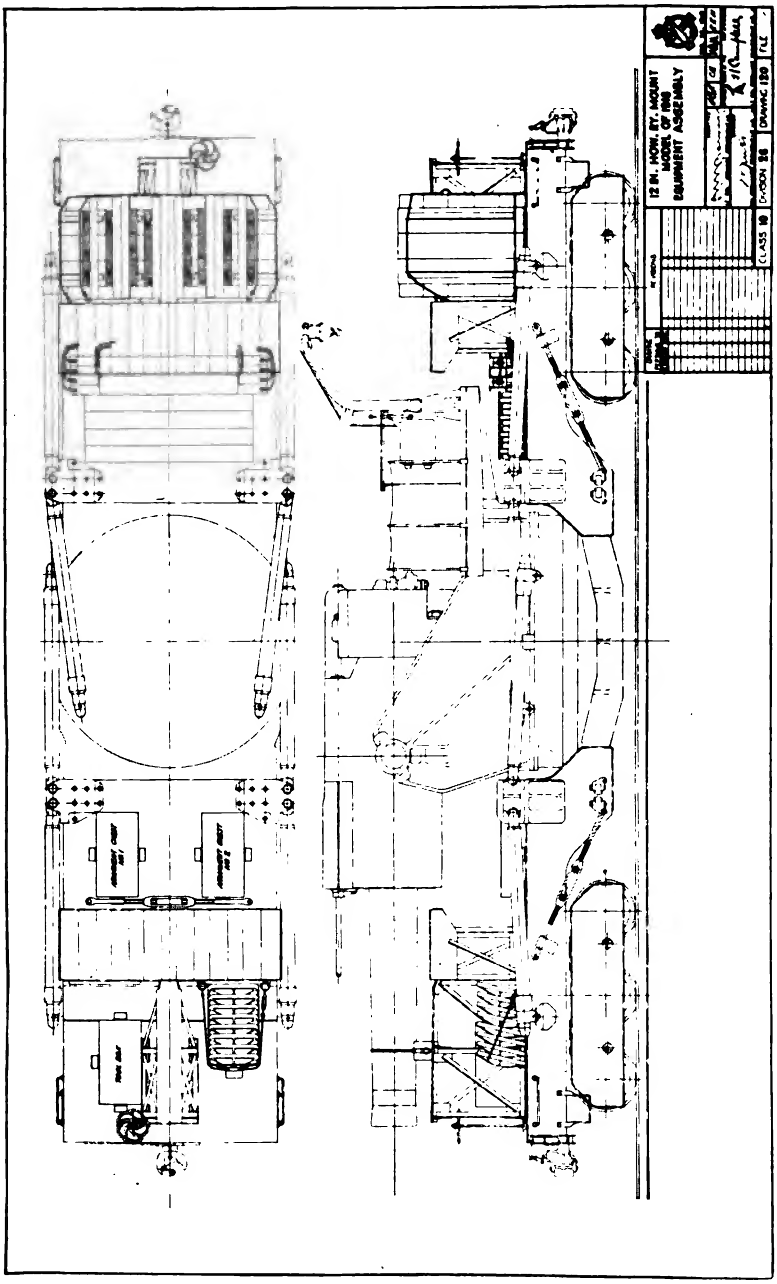


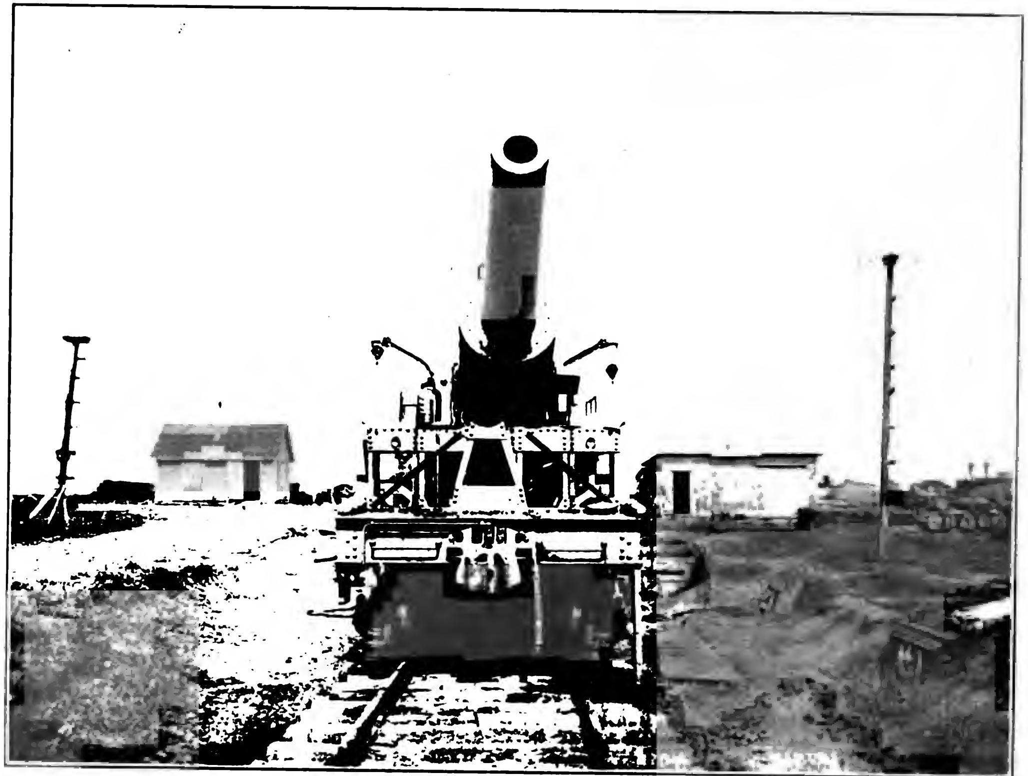
PLATE 182

12-INCH, 20-CALIBER AMERICAN HOWITZER AND MOUNT (RIGHT SIDE).

PLATE 103

12-INCH, 20-CALIBER AMERICAN HOWITZER AND MOUNT (LEFT SIDE)

PLATE 194



12-INCH 20-CALIBER AMERICAN HOWITZER AND MOUNT (FRONT).

Plate 195

12-INCH 20-CALIBER AMERICAN HOWITZER AND MOUNT (REAR).

Plate 196

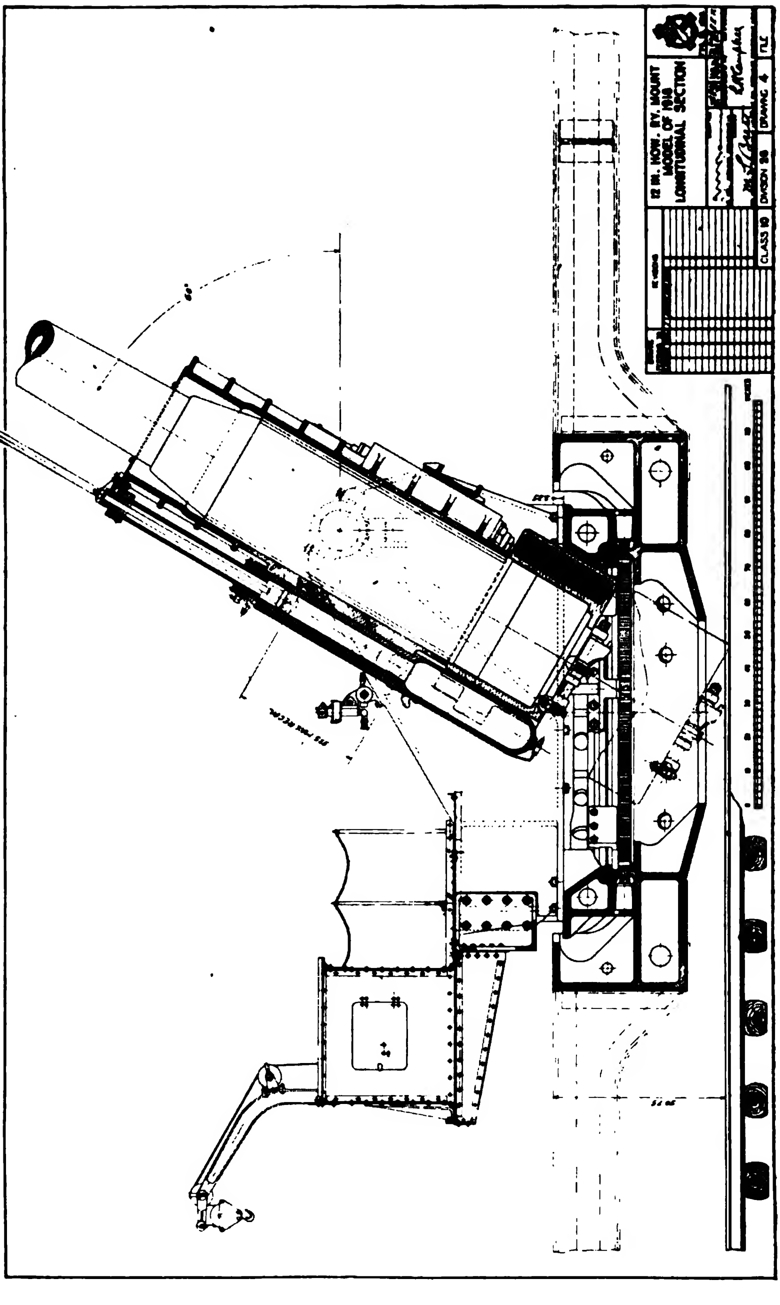


PLATE 197

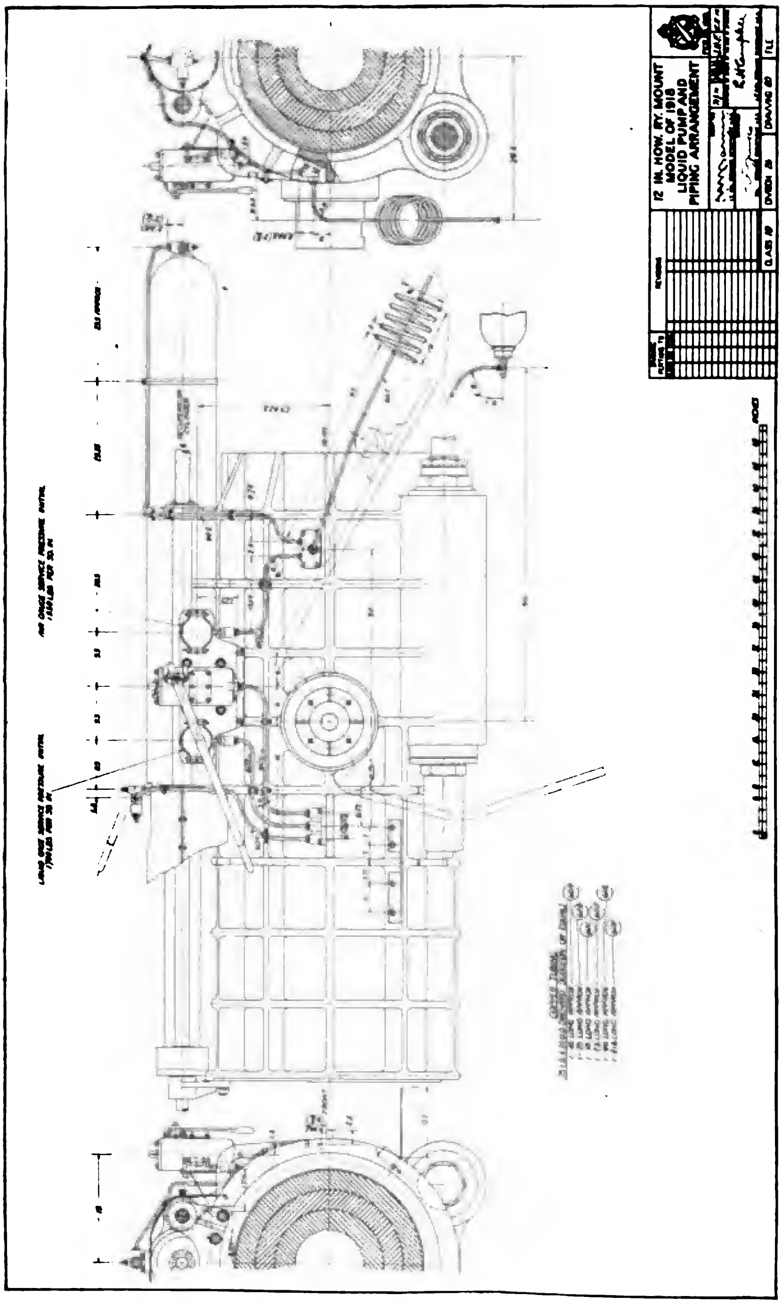

12 IN. HOW. RY. MOUNT
MODEL OF 1918
LIQUID PUMP AND
PIPING ARRANGEMENT

PLATE 198

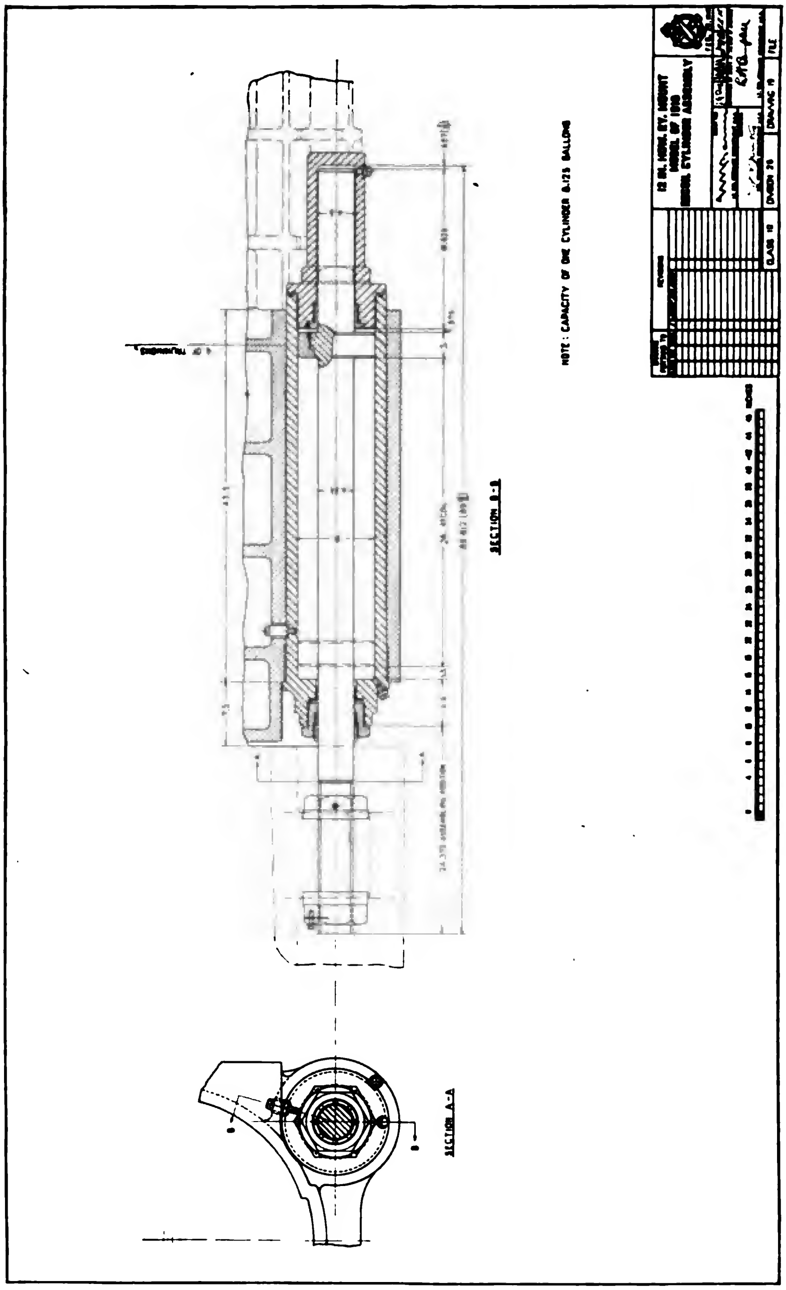

NOTE: CAPACITY OF ONE CYLINDER 0.125 GALLONS
SECTION B-B
SECTION A-A

PLATE 109

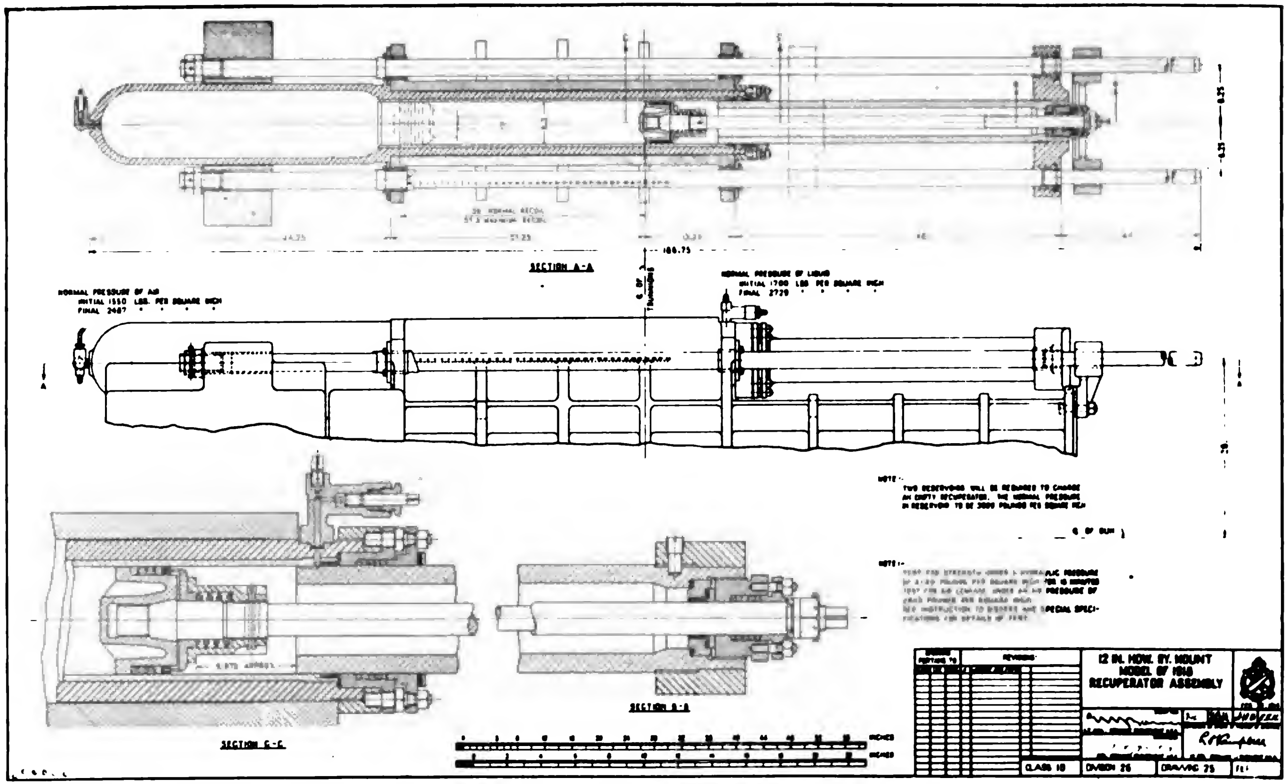

SECTION A-A
SECTION B-B
SECTION C-C
NORMAL PRESSURE OF AIR
INITIAL 1550 LBS. PER SQUARE INCH
FINAL 2467
NORMAL PRESSURE OF LIQUID
INITIAL 1700 LBS PER SQUARE INCH
FINAL 2729
12 IN. HOW. RY. MOUNT
MODEL OF 1918
RECUPERATOR ASSEMBLY
CLASS 18
DIVISION 26
DRAWING 25

Plate 200

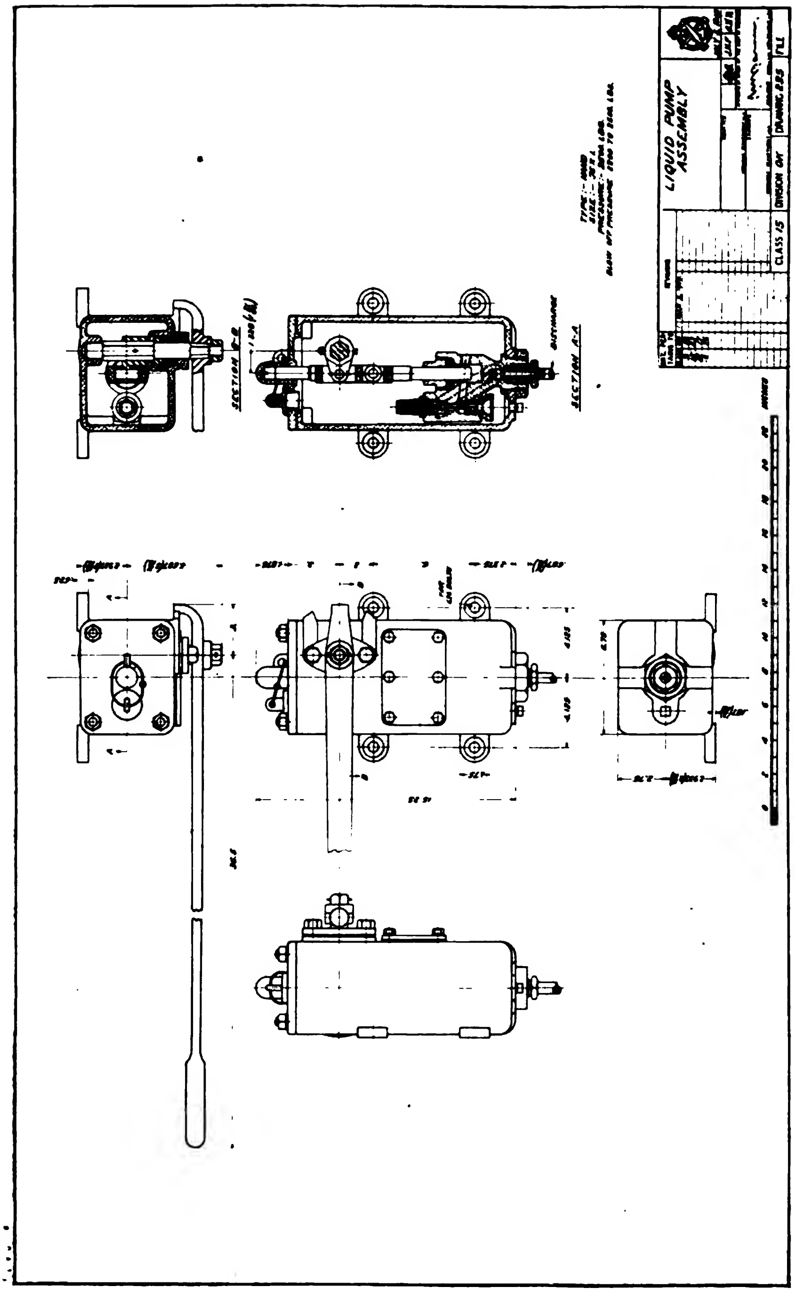

LIQUID PUMP
ASSEMBLY
SECTION B-B
SECTION A-A
CLASS 15
DIVISION OF

PLATE 201

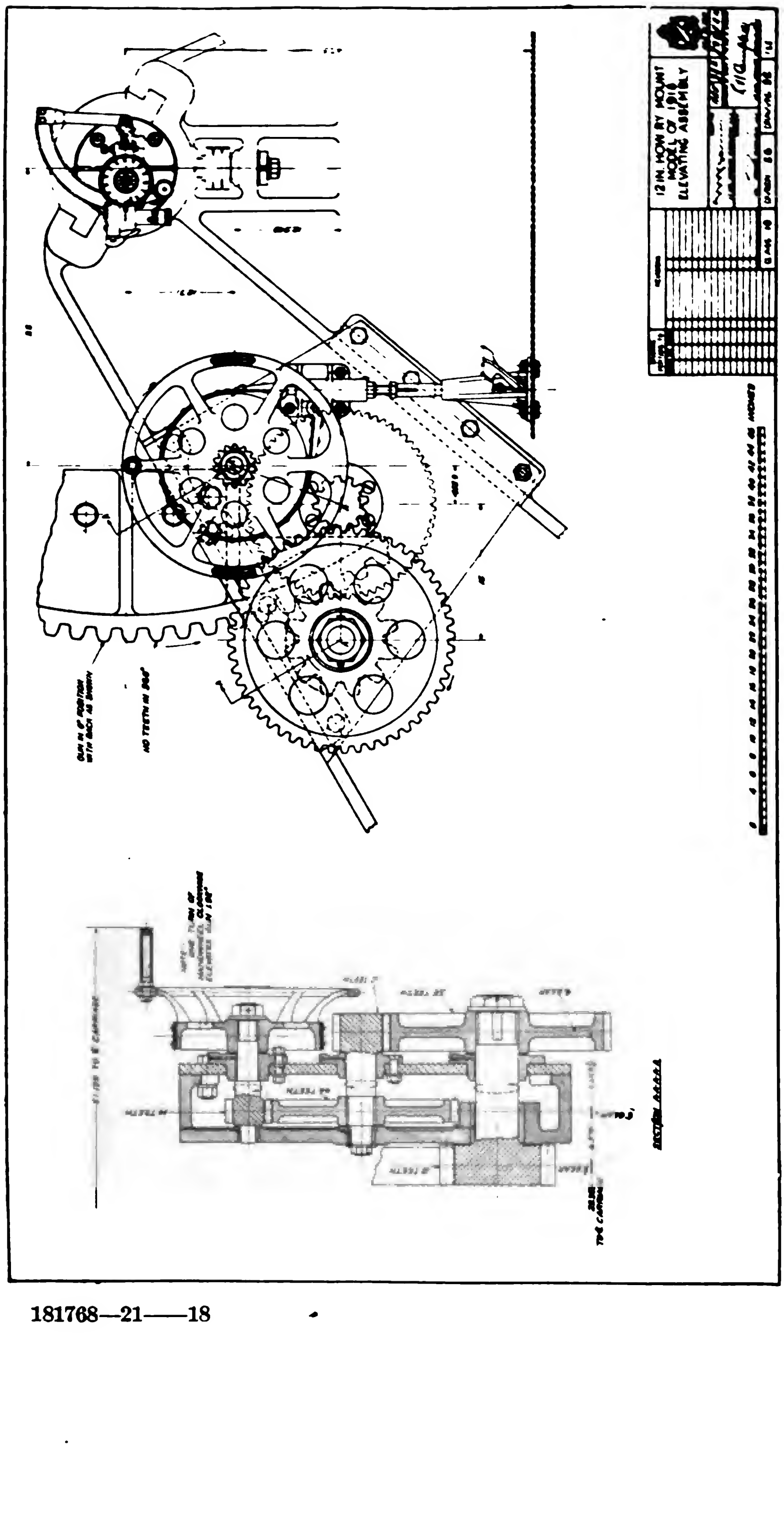


PLATE 202

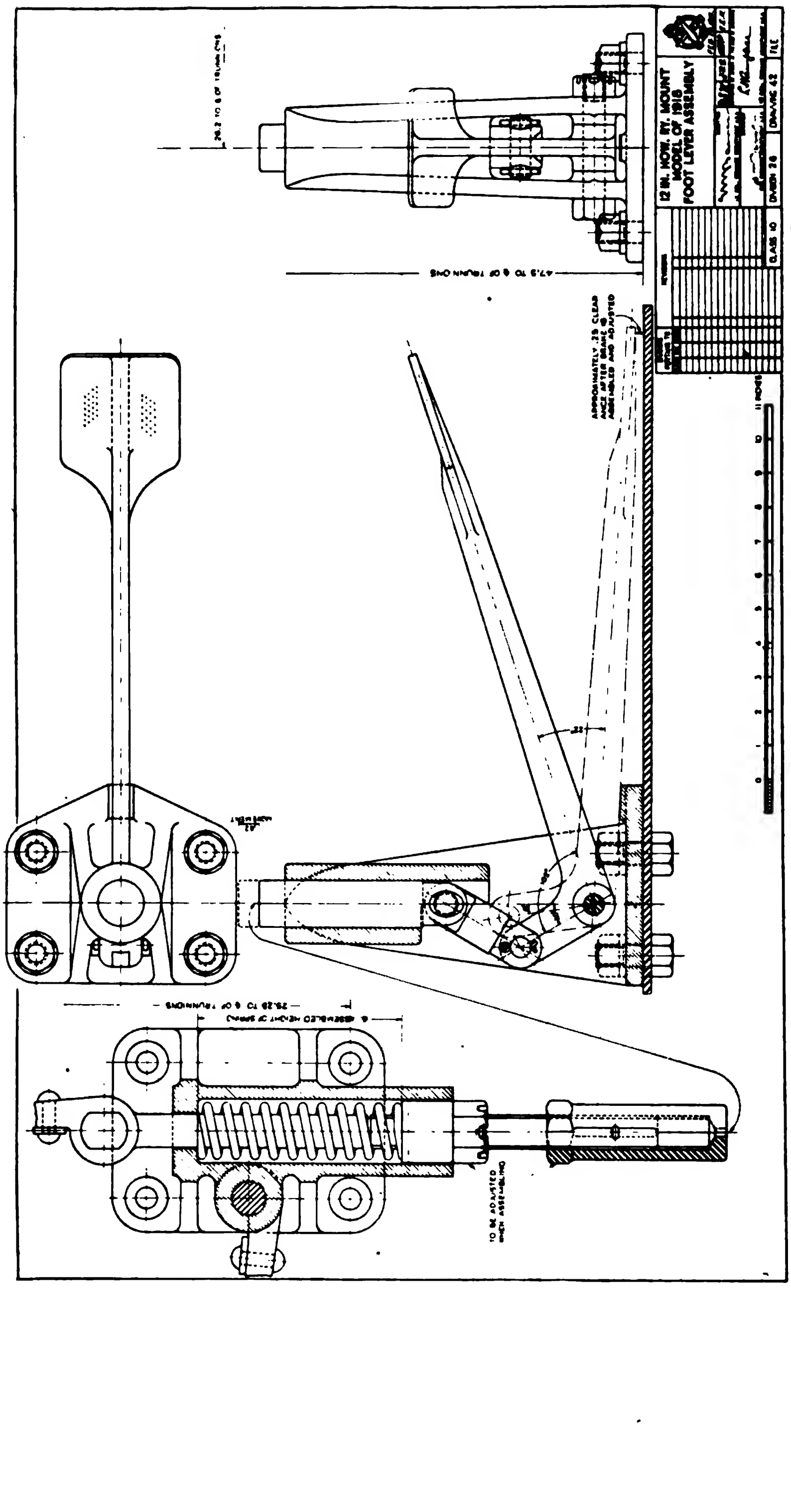

12 IN. HOW. RY. MOUNT
MODEL OF 1918
FOOT LEVER ASSEMBLY
CLASS 10
DIVISION 26
DRAWING 42
FILE
47.5 TO ℄ OF TRUNNIONS
25.25 TO ℄ OF TRUNNIONS
APPROXIMATELY .25 CLEARANCE AFTER BRAKE IS ASSEMBLED AND ADJUSTED
TO BE ADJUSTED WHEN ASSEMBLING
11 INCHES

PLATE 203

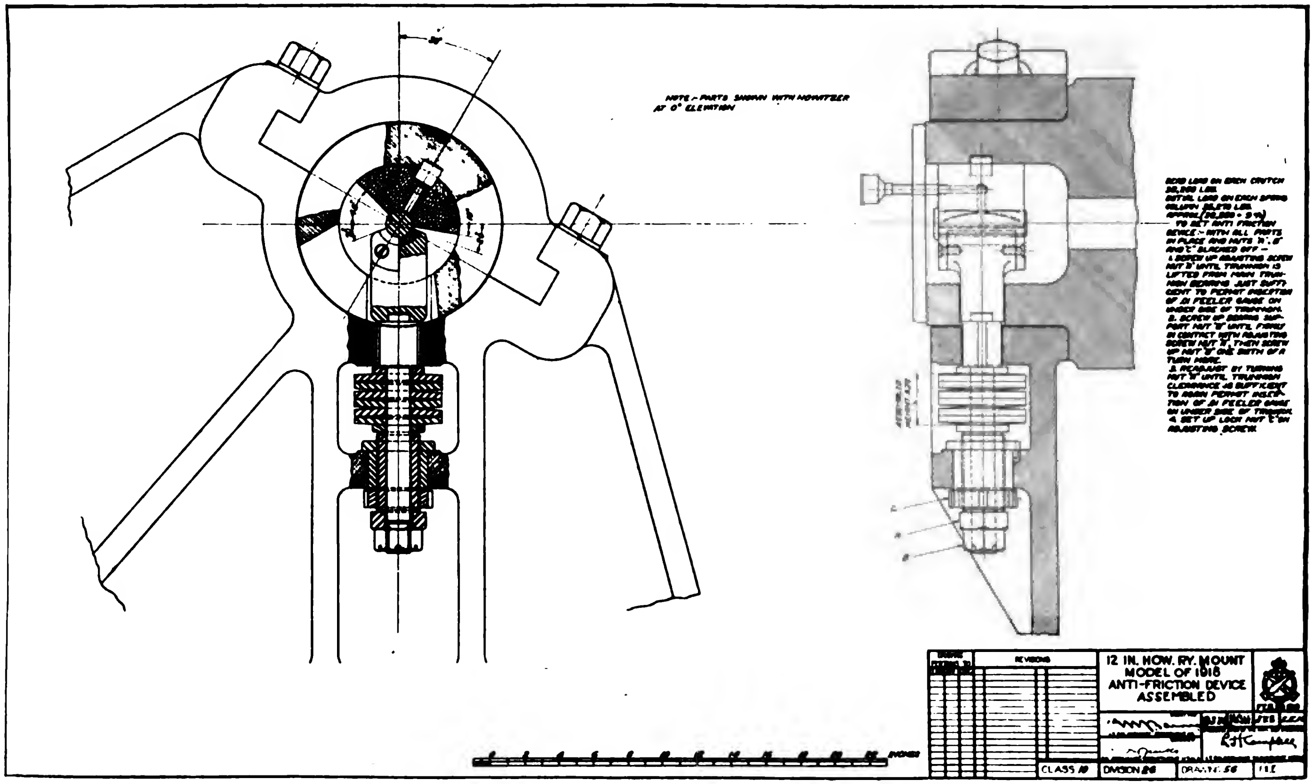

NOTE – PARTS SHOWN WITH HOWITZER AT 0° ELEVATION
12 IN. HOW. RY. MOUNT MODEL OF 1918 ANTI-FRICTION DEVICE ASSEMBLED
CLASS 10
DIVISION 26
REVISIONS

Plate 204

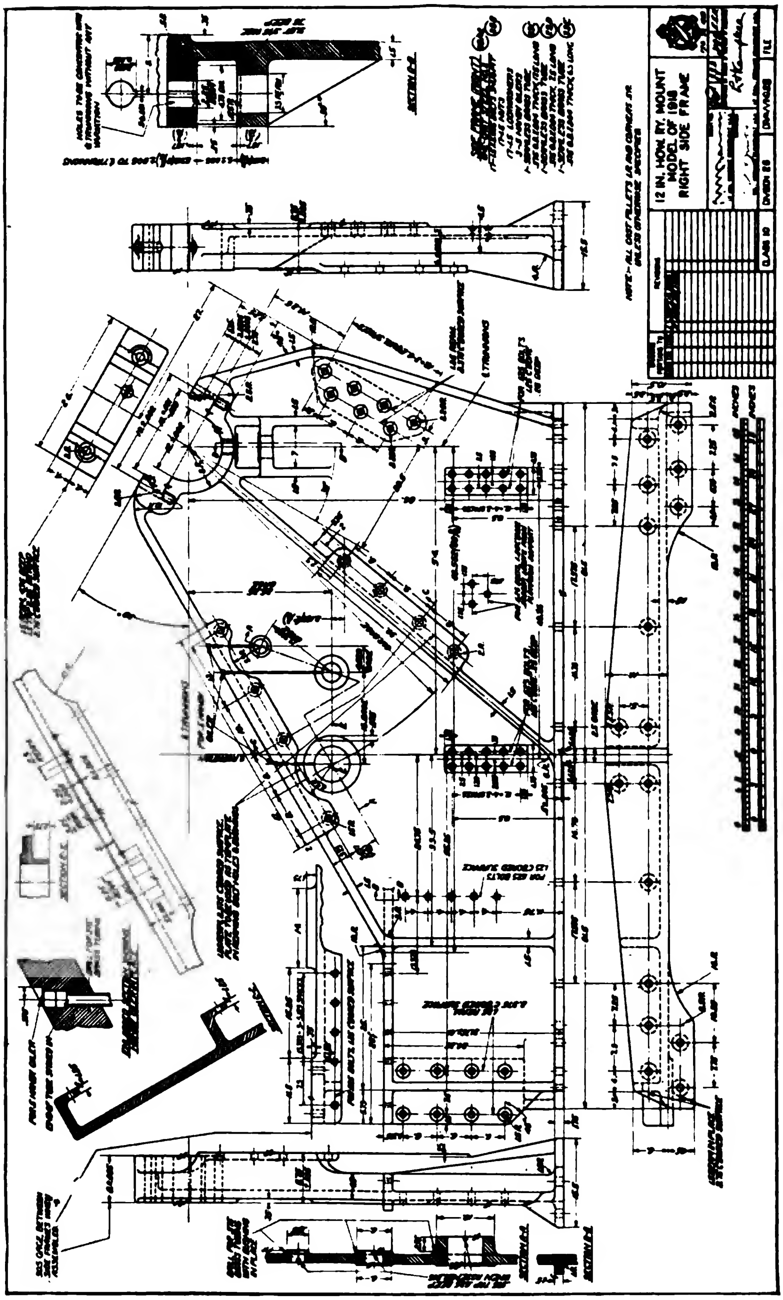


PLATE 205

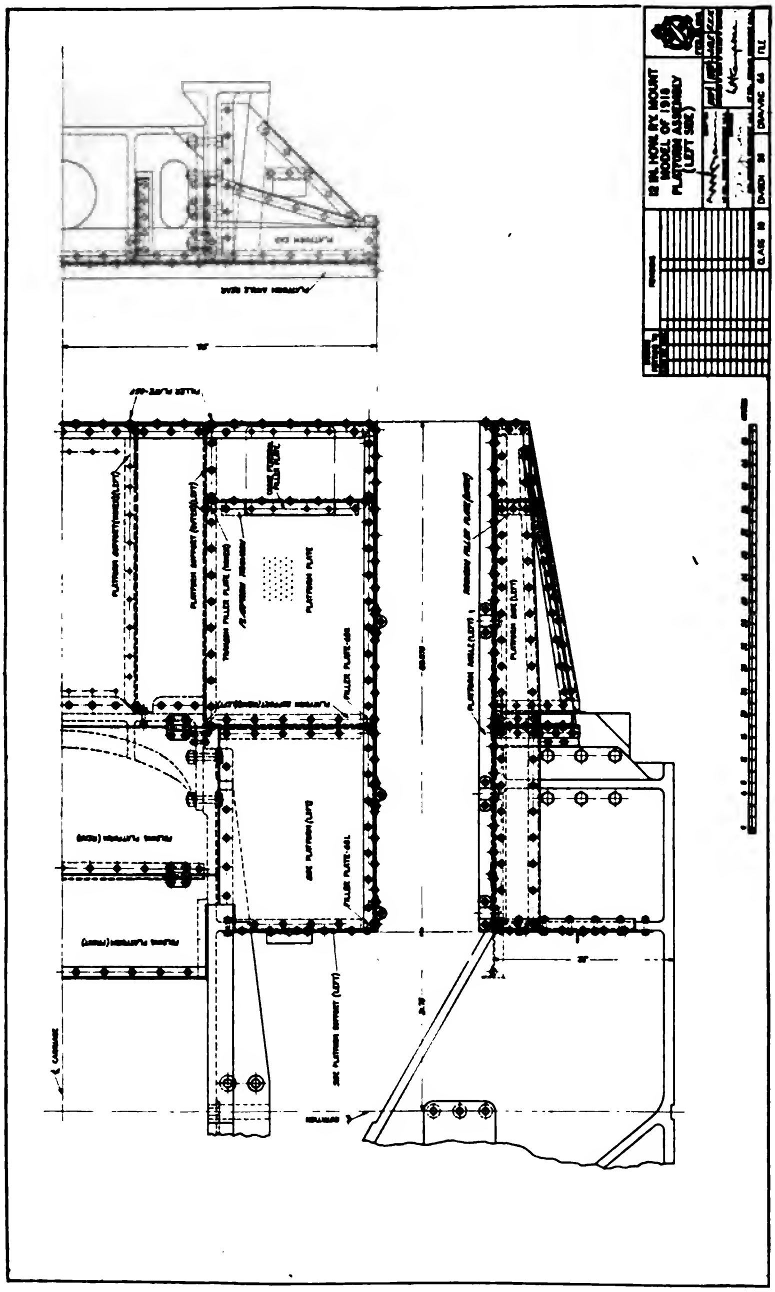


PLATE 206

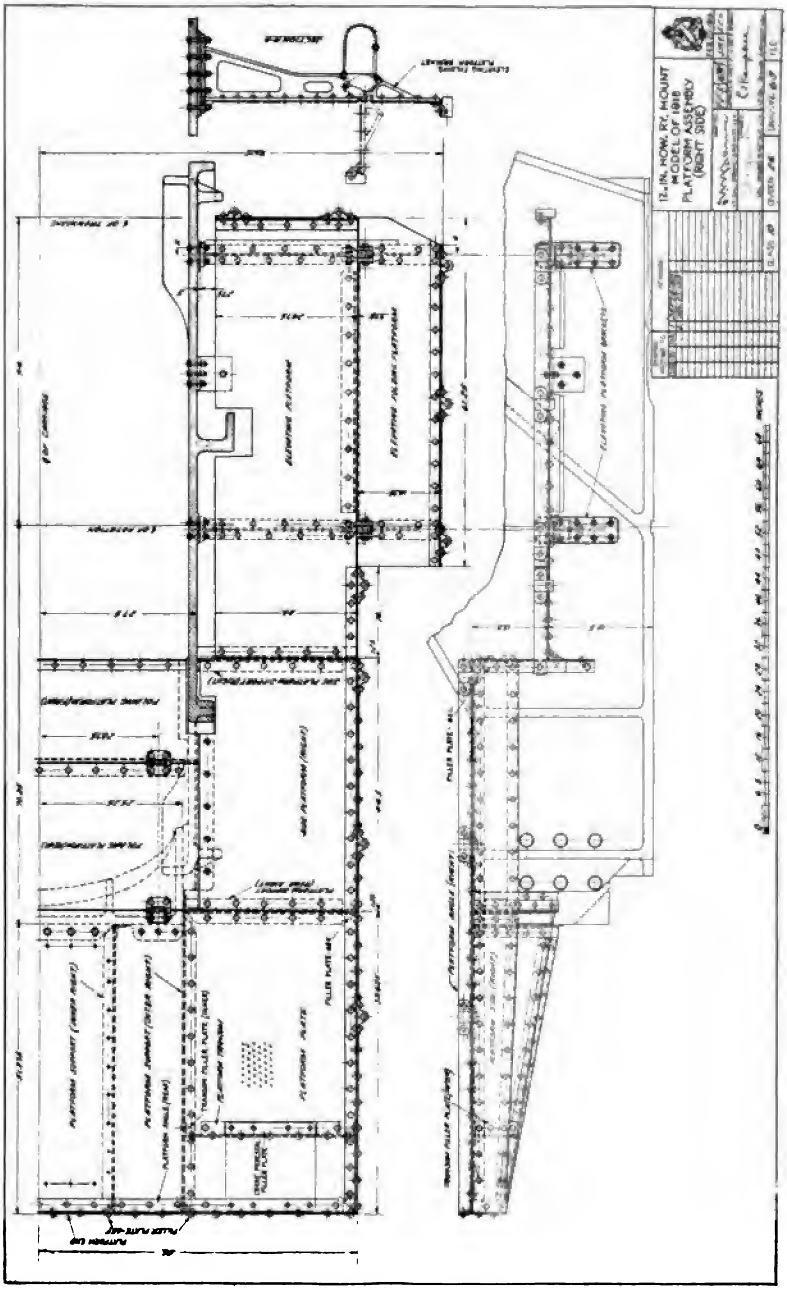

12-IN. HOW. RY. MOUNT
MODEL OF 1918
PLATFORM ASSEMBLY
(RIGHT SIDE)

Plate 207

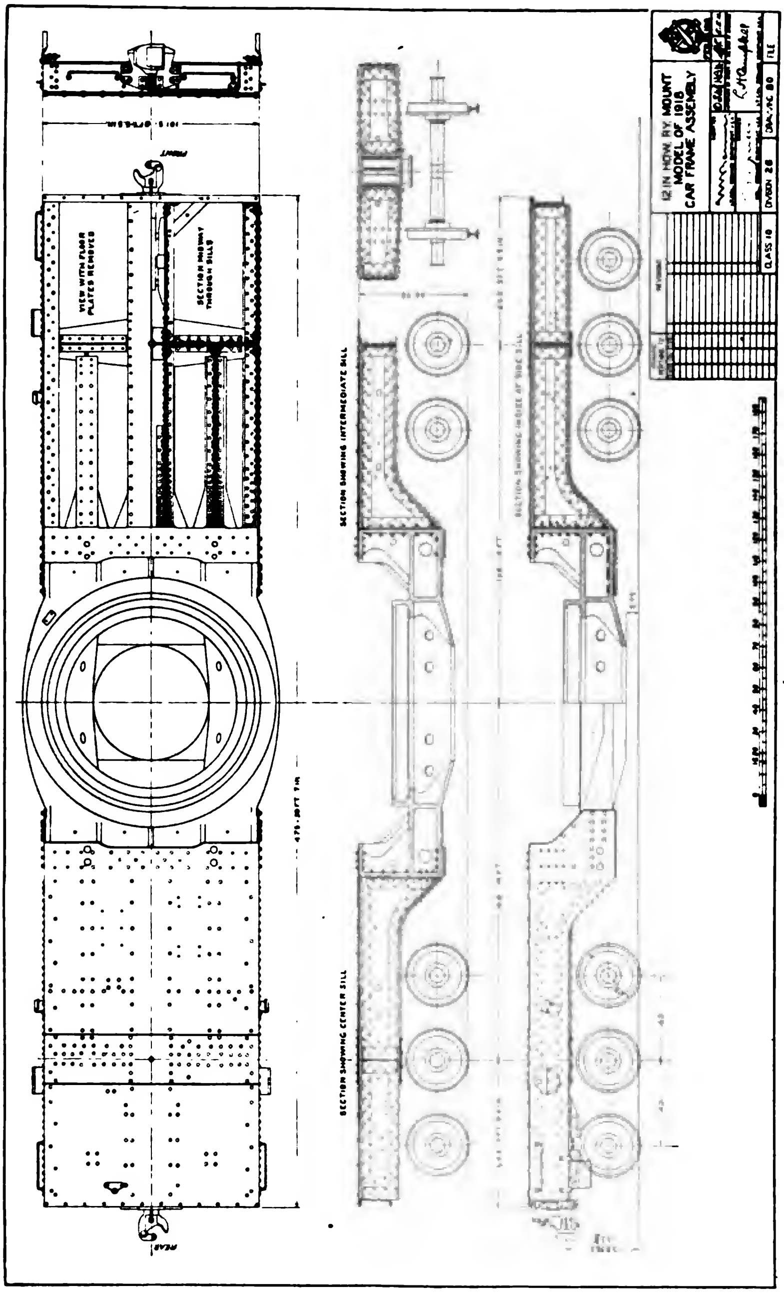

12 IN. HOW. RY. MOUNT
MODEL OF 1918
CAR FRAME ASSEMBLY
VIEW WITH FLOOR PLATES REMOVED
SECTION MIDWAY THROUGH SILLS
FRONT
REAR
SECTION SHOWING INTERMEDIATE SILL
SECTION SHOWING CENTER SILL
SECTION SHOWING INSIDE OF SIDE SILL
CLASS 10
DIVISION 28

PLATE 208

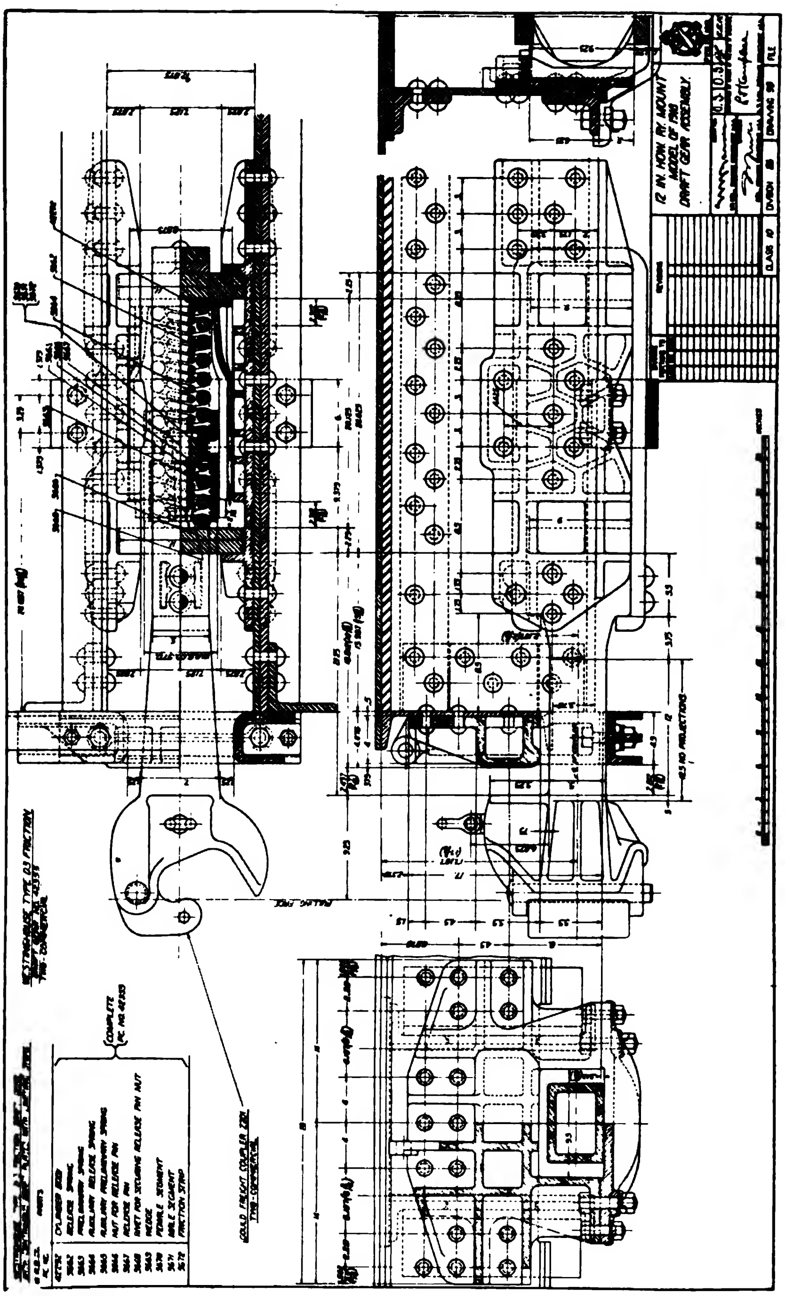


PLATE 200

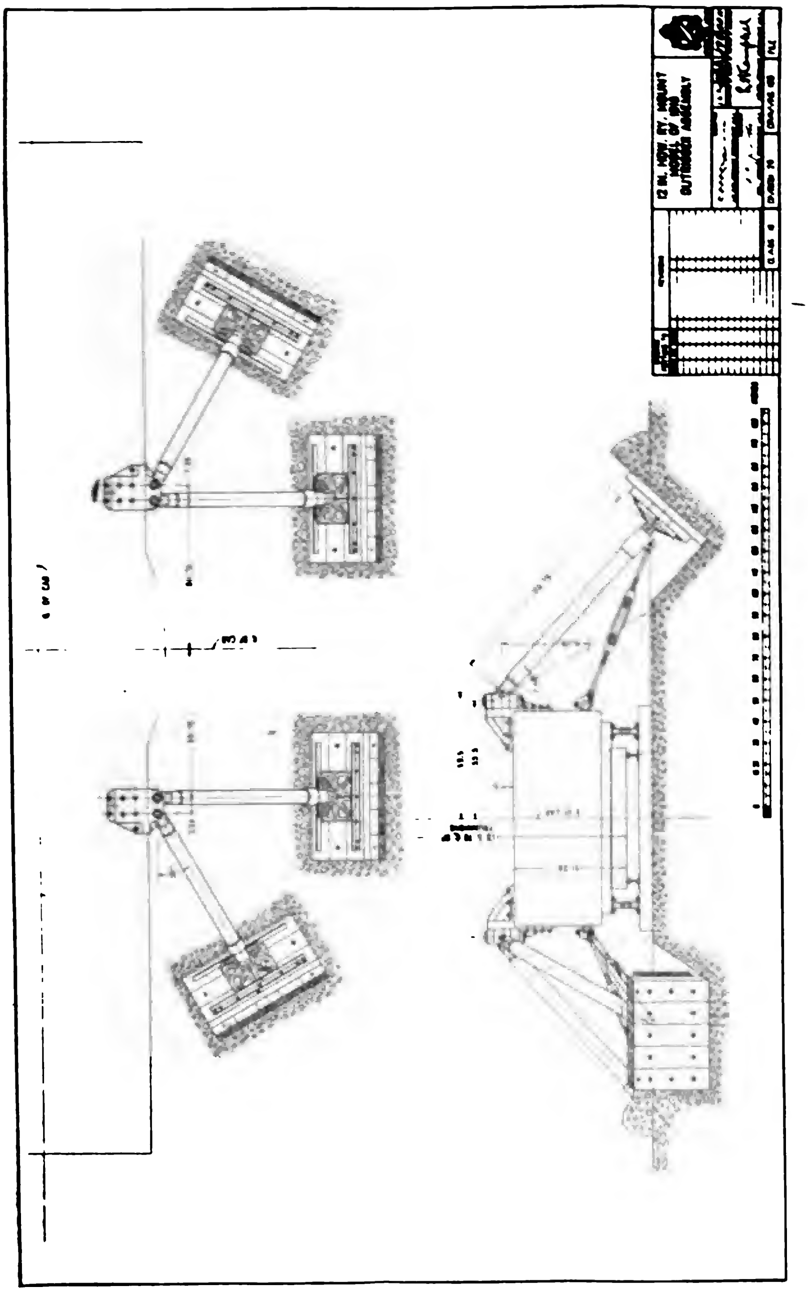


PLATE 210

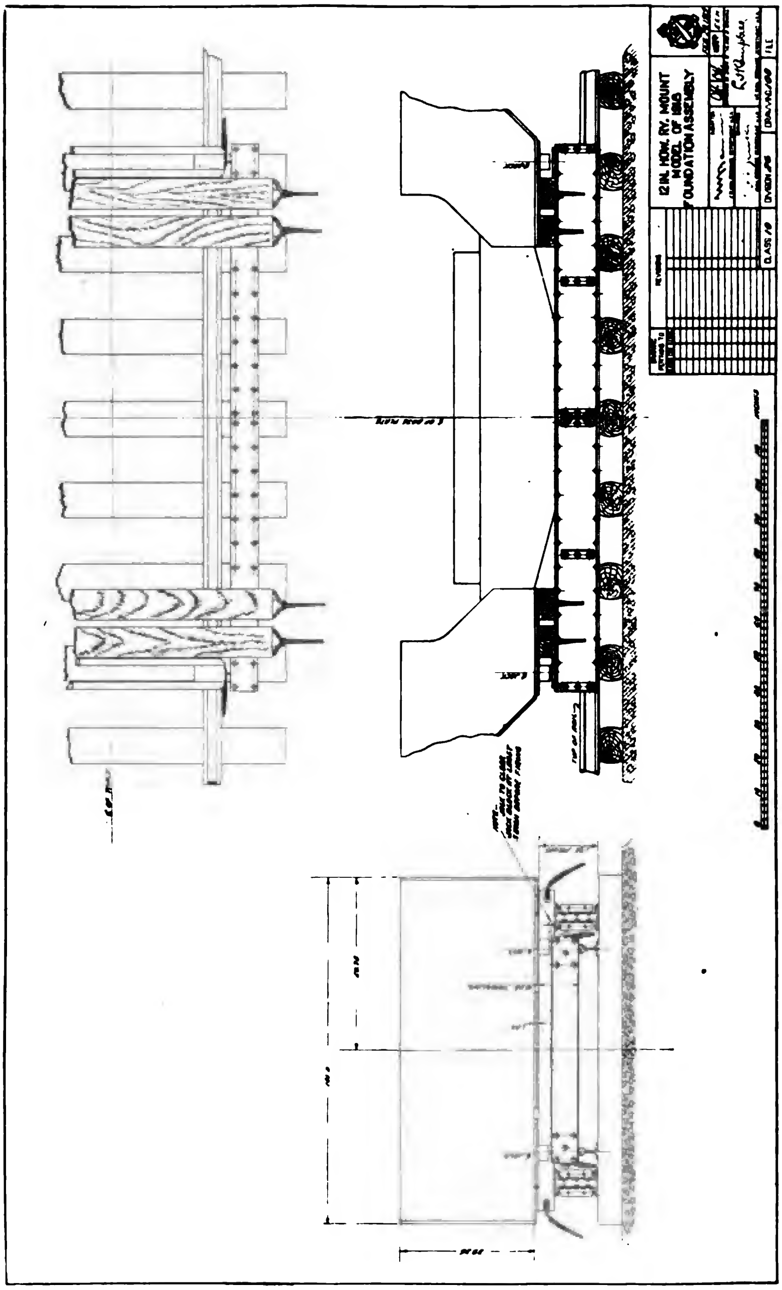


PLATE 211

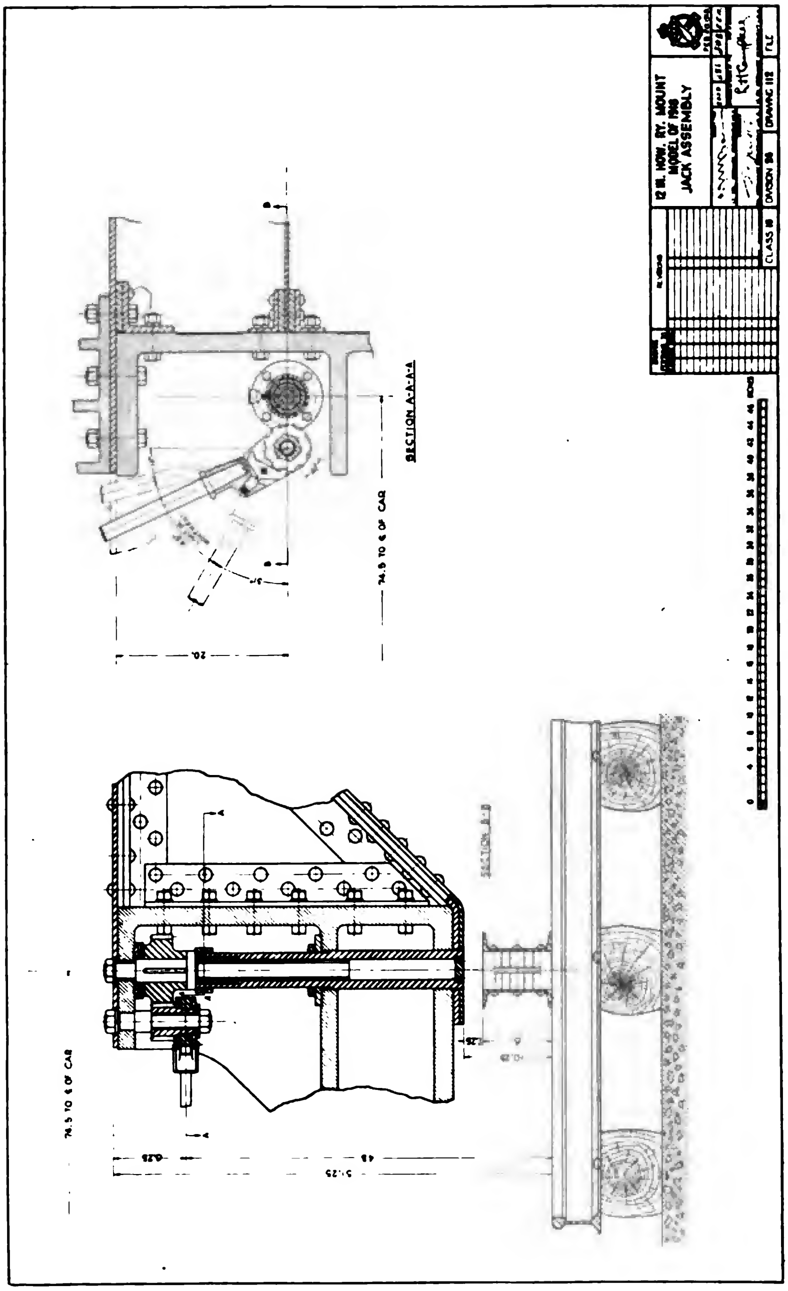

12 IN. HOW. RY. MOUNT
MODEL OF 1918
JACK ASSEMBLY
SECTION A-A-A-A
SECTION B-B
74.5 TO ℄ OF CAR
20.
CLASS 18
DIVISION 36
DRAWING 112
FILE

PLATE 212

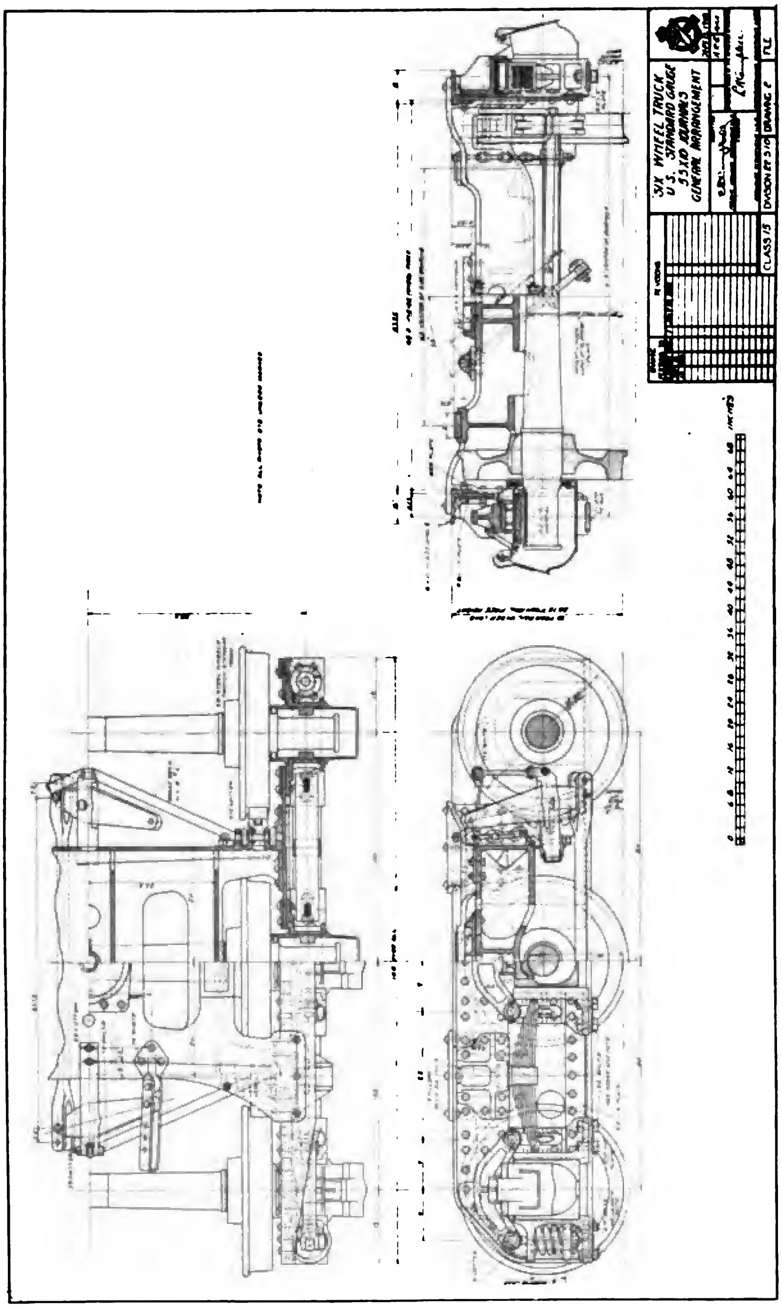

SIX WHEEL TRUCK
U.S. STANDARD GAGE
5½X10 JOURNALS
GENERAL ARRANGEMENT
CLASS 15

PLATE 213

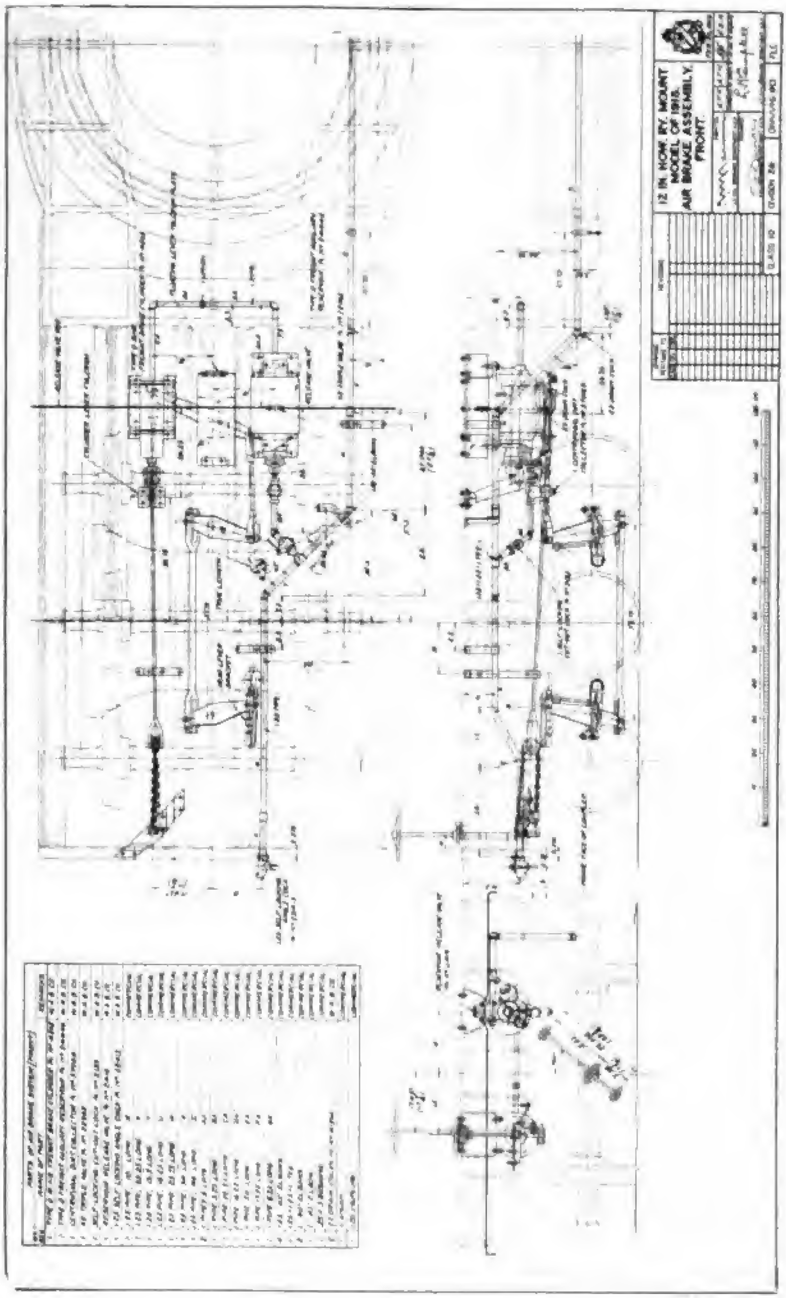


PLATE 214

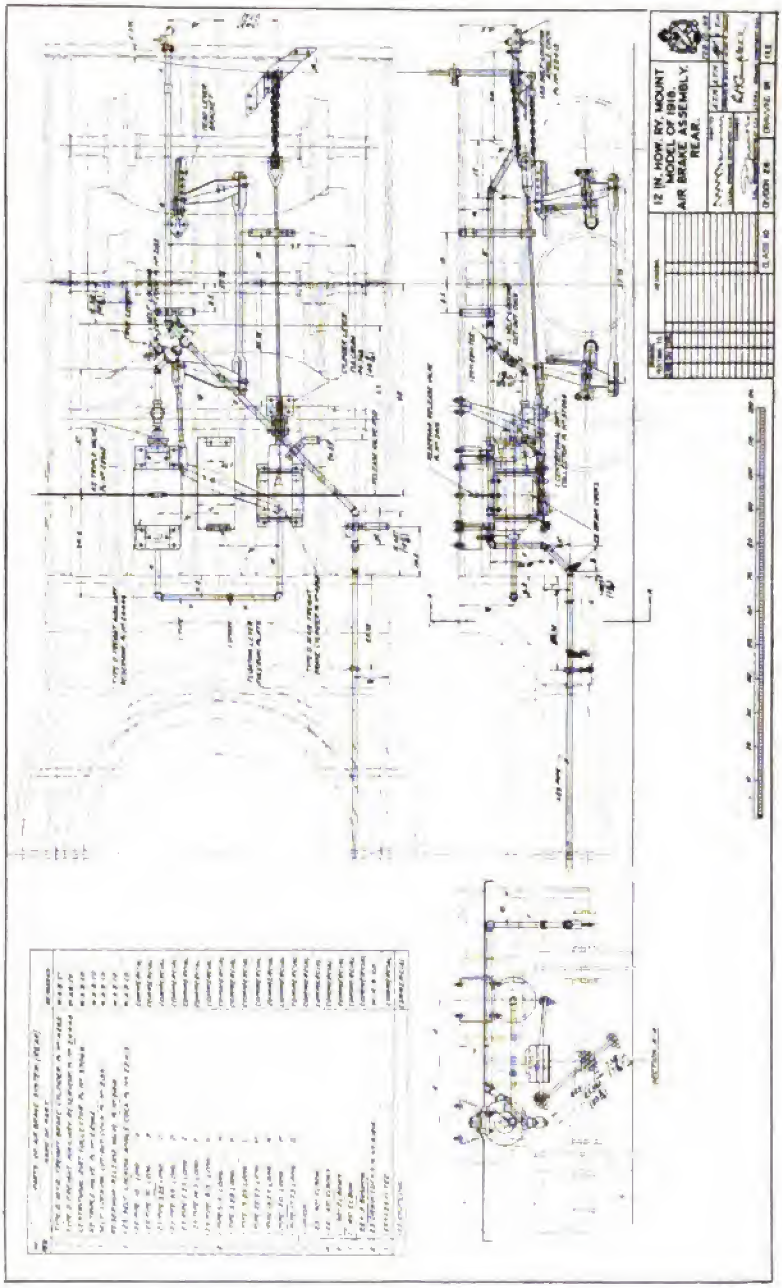
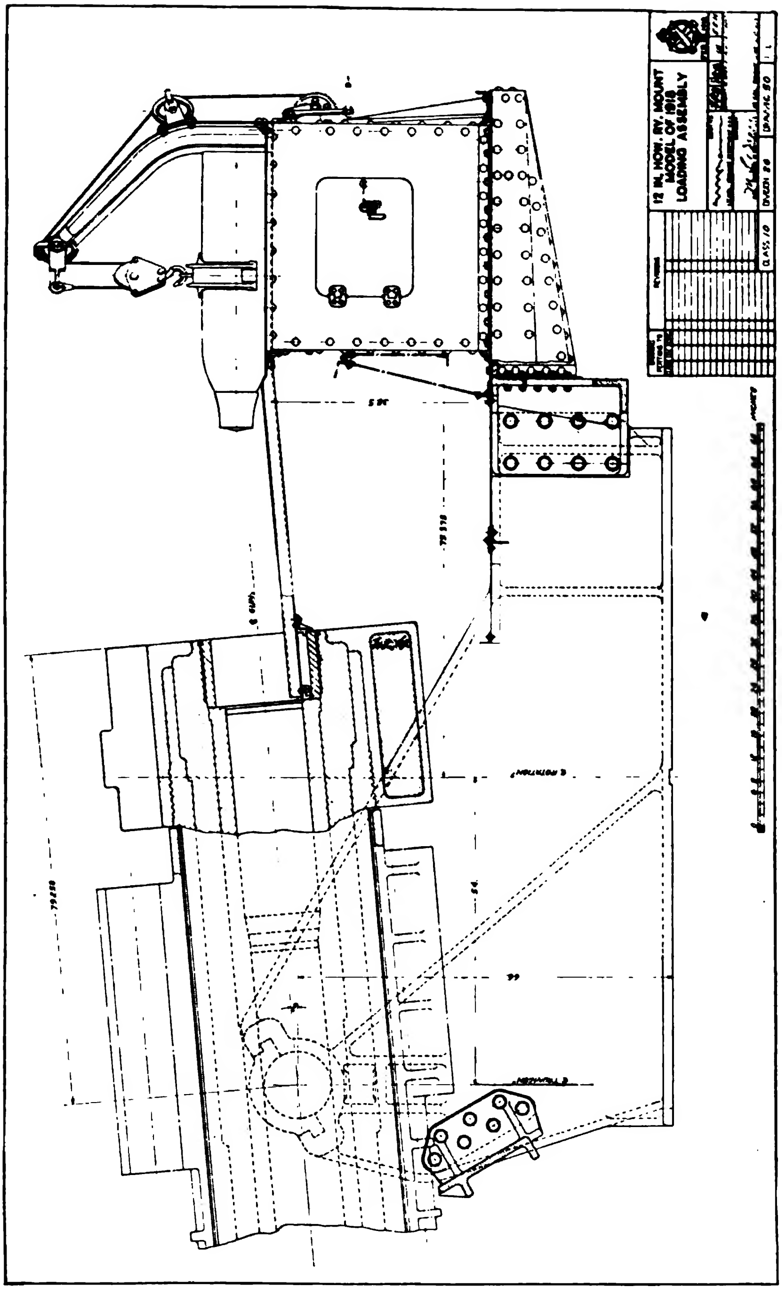


PLATE 215


12 IN. HOW. RY. MOUNT
MODEL OF 1918
LOADING ASSEMBLY
CLASS 10
DIVISION 80
DRAWING 80

9.—14-INCH GUN ON RAILWAY MOUNT, MODEL E. (22)

206. This is a mount the design of which was practically finished prior to our entrance into this war. It was designed primarily for service in the coast defenses, although a number of special provisions were made for its service as a field mount and even those features which adapt it especially for coast defense, adapt it likewise for certain types of field service. It can be operated either as a sliding or as a fixed emplacement mount. Only one mount of this design has been finished, but it has made so favorable an impression from its performance in recent tests against a moving target, at a distance of 6,000 yards, when the difficulties of following a rapidly moving target are extreme, that it is probable that a new mount embodying most of its desirable features, as well as other features found imperative for field service, will be made up very shortly. General views are shown on plates 217, 218, 219, and 220.

207. GUN.—The piece used on this mount is a wire-wound 14-inch gun, model 1919, of 40 caliber length. It is provided with an interrupted thread breech, which is fitted with a mechanical firing mechanism. There are 126 grooves and the twist of the rifling is to the right, progressing from one turn in 50 calibers to one turn in 25 calibers.

208. RECOIL MECHANISM.—The recoil mechanism is of the hydro-spring type and is composed of one hydraulic recoil cylinder attached to the bottom of the cradle in the center, and of the design shown on plate 221, and six spring recuperator cylinders arranged about the cradle and of the design shown on plate 222. This recoil mechanism has functioned very satisfactorily in all of the tests so far conducted. It is quite probable, however, that a pneumatic recuperator will be substituted for the spring recuperator on the new design that will be made up for other 14-inch guns. There are no features in the design of either the recoil cylinder or spring recuperator that are unusual. The maximum length of recoil is 60 inches. A by-pass providing an additional oil passage between the end of the buffer and outlet on the bottom of the cylinder is shown on plate 221. This is provided to permit of an adjustment to secure the full recoil of the gun at low elevation as well as for reduced powder charges.

209. ELEVATING MECHANISM.—Provision is made for elevating the gun from its loading angle, zero degrees, to a maximum elevation of 30 degrees The details of the elevating mechanism are shown on plates 221 and 223. This elevating mechanism is essentially the same in design as that provided on the 14-inch Navy mounts, Marks I and II. It will be observed on the above noted plates that the mechanism is made up of one large screw hinged to the bottom of the cradle by means of a yoke and trunnions and passing through a large nut in the oscillating housing which is in

turn supported by its trunnions in bearings attached to the car body. This nut is provided with a ball thrust bearing as shown on plate 223, and is driven by miter gears which communicate with the handwheel through the horizontal cross shaft and two more sets of miter gears. The elevating handwheel is mounted on the right side of the carriage just behind the trunnion. Each trunnion is equipped with an antifriction device of the design shown on plate 224. This is of the rolling wedge or knife edge type and again is almost identical in design with the antifriction device provided on the Navy 14-inch mounts, plate 270. It is composed of a fulcrum arm whose rounded lower end rests in a bearing block which in turn rests on the adjusting wedge. The upper end of the fulcrum arm is rounded to a radius equal to the distance from the center of the lower end to the center of the top, and bears directly against the under side of an extension of the main trunnion. Both the fulcrum arm and the trunnion are fitted with gear-toothed segments which mesh with each other and prevent slipping of the arm. The device is adjusted by means of the wedge under the bearing block at the bottom of the arm. When properly adjusted, this device carries the weight of the gun while it is being elevated and depressed, thereby reducing considerably the effort required. When the gun is fired the force of recoil is transmitted, even at the maximum firing angle of 30 degrees, almost entirely into the main trunnion bearing. This mechanism is inferior to the type used in the service of the other mounts already described, in that it contains no flexible parts that can bend or be compressed under the force of recoil and permit that force to be communicated more easily and directly to the main trunnion bearings. One turn of the slow, operating handwheel elevates the gun through 0.33 degree and one turn of the fast-operating crank elevates the gun through 0.545 degree.

210. Traversing Mechanism.—This mount can be traversed through 360 degrees by means of a mechanism, the design and details of which are shown on plates 225, 226, and 227. The entire mount rests by means of four conical rollers on a cast-steel base plate. To the center of the base plate is bolted a pintle which takes the horizontal component of the force of the recoil; gears are cut on the inside of the roller path to serve as a traverse rack. The traverse pinion is cut in the bottom end of a vertical shaft which can be raised for traveling, or lowered to mesh with the traversing rack for traversing the mount. This shaft passes through and is driven by the large horizontal miter gear, as shown on plate 227, which is in turn driven through miter gears by the two handwheels on the sides of the carriage. The gear case through which the horizontal driving shaft passes on the left side of the carriage, plate 227, contains a

large miter gear, loose on the shaft, but which may be thrown into gear with the shaft by the foot-pedal operated clutch. When the clutch engages the miter gear, the traversing mechanism is operated by the handwheel somewhat to the rear of the handle and shown on plate 218. This gear is used for the final fine adjustment.

211. It has been noted before that the gun can be fired without the use of a firing platform to an elevation of 22 degrees. To secure any great amount of traverse under this elevation, it is of course necessary to operate the mount on a curved track. For fine adjustment, a car body traversing mechanism of the design shown on plates 228 and 229 is used. It will be observed here, that cast-steel body bolsters shown in detail on plate 230, riveted into each end of the car, carry a traversing beam which is fixed with respect to the truck when the lifting bolster is down. Between this traversing beam and the body bolster are two rollers, 5.33 inches in diameter and 23 inches in length, on each end of which are cut spur gears which mesh with racks attached to the body bolster and the traversing beam. The traversing beam is connected with the handwheel on the left side of the carriage, plates 218 and 228, by means of a screw and spur gears. The mount is capable of being traversed 0.25 degree on each side of the center, at each end of the car, by means of this mechanism, thereby securing a total traverse of 1 degree. One turn of the handwheel moves one end of the car through 0.093 degree. As the handwheel is turned, the traversing screw moves either in or out of the traversing beam. As noted before, the traversing beam is fixed with respect to the trucks the car body must therefore mov on the traversing rollers.

212. Gun Carriage.—In this mount the gun carriage is incorporated with and is a part of the car body. The gun is carried in a cast-steel cradle which is swung directly by means of its trunnions, between the side girders of the car body.

213. Car Body.—The car body is made up of two single-web structural steel side girders connected by a series of structural and cast steel transoms, plate 230. The cast-steel body bolsters at the front and the rear, the cast-steel pintle bearing in the center at the bottom, and the cast-steel jack bolster at the rear serve further to stiffen it. Two cast-steel side frame yokes serve further to stiffen the car body at the top and one carries the forward end of the I-beam ammunition trolley, plate 243.

214. Anchorage.—The mount may be operated to an elevation of 22 degrees without the use of auxiliary anchorage equipment, if desired. To this elevation it may be operated as a sliding type mount. On plates 231 and 232 are shown the cast-steel sliding shoes which are bolted to the bottom of the lower chords of the side girders at the front and the rear. These shoes bear on two auxiliary rails placed on

the ties one on the outside of each of the service rails. When ready for firing the mount is let down until the entire weight rests on the auxiliary rails through these shoes. In a series of trials that have been made, the length of recoil varied from 11 to 17 feet.

215. For firing above angles of 22 degrees, it is necessary to place the mount on the cast-steel base ring, the design of one half of which is shown on plate 233. This base ring may be laid either on a concrete sub-base or on rock ballast. When placed on rock ballast, it is necessary to brace it against lateral movement by means of 64 steel piles, 4 feet long, driven around its circumference. The base ring is in halves and in traveling is carried on a standard flat car, as shown in plate 234. The full capacity of a 160-ton locomotive crane is required to handle it in process of installation. It is first removed from the car and placed on the ground beside the emplacement, as shown on plate 235. On plate 234 a lifting eye will be observed attached to the hinge pin between the two sections. After the base has been placed on the ground, it is picked up first by means of this eye, as shown on plate 236, after which two chains are attached to the two half segments. The platform is then spread, plate 237, and laid in place on the leveled ballast surface of the prepared position, plate 238. The two segments are then bolted together with eight bolts on each side of the center and the steel piles driven around the circumference, plate 239. Four special rail sections are placed over the conical roller path and are bolted to the rails of the approach track. After these rail sections are installed, the mount is run into position over the emplacement and lowered until the traversing rollers rest on the roller path and the pintle engages with the pintle bearing, plate 240.

216. The mount is lowered by means of two identical lifting devices installed on the front and rear trucks and of a design shown on plates 228 and 229. Above the center of the front truck, plate 218, a capstan mounted on the shaft of the pinion, which drives this lifting gear, can be seen. This pinion meshes with two large spur gears which are attached to the ends of identical screws which screw into the lifting bolster. As the capstan is turned and drives these screws, the bolster is raised or lowered with respect to the car, thereby lowering the car onto, or raising it from the emplacement. This device is supplemented by a hydraulic lift, incorporated in the center plate of the truck. However, when this is used the movable bolster must be raised or lowered by hand to maintain the side bearing clearance and prevent the mount from overturning. The lifting bolster is shown in its traveling position on plate 228. On plate 229 it is shown as located when the mount is resting on the emplacement and the trucks are removed or ready to be removed. The eight conical traversing rollers, plate 240, are removed in traveling.

217. When the lifting bolsters are raised the mount can be traversed until the rear end is over the supports, plate 241. This supporting device with the support beams is shown on plates 242, 243, and 244. The cast steel support beams are made up in segments and are placed on short sections of I-beams which rest directly on stone ballast. A cast steel transom carrying two hydraulic jacks and one screw jack is riveted to the rear of the car body. These hydraulic jacks have swinging shoes which rest on the support beams and serve to prevent the mount from turning over in firing. Tests have been made which prove that the mount can be operated without supports of this kind when the base ring is bolted to a concrete subbase. The design of the hydraulic support cylinder is shown on plates 244 and 245. No special mechanism is provided for raising or lowering the hydraulic cylinders. They can easily be raised or lowered by any sort of lever, such as a crowbar, and move easily when moved very slowly. In preparing for action the supporting beams are leveled very carefully and the hydraulic jack shoes are lowered until they bear on the greased top surface of the supports. A small cable is attached to the top of the movable cylinder and passes over the top of the pulley to the counterweight which balances its weight. The cylinder will remain in any position. As the cylinder moves up or down, the oil between it and the ram must pass through the valve shown in the center of the bottom of the ram, plate 245. Any attempt to move the cylinder rapidly as is the case when the gun is fired, simply serves to close this valve and prevent the cylinder from moving. Thus the cylinder can be brought down until its bearing plate rests on the support segments, and inasmuch as it exerts no pressure, no difficulty is caused in traversing; but the cylinder furnishes a positive support in firing, since as noted above, any attempt to move it rapidly closes the valve in the ram. The top surface of the support beams is kept well greased.

218. Trucks.—The trucks are constructed of structural steel and steel castings and carry four axles each with 6 by 11 inch outside journals and 31-inch wheels. Both hand and air brakes are provided. The two trucks are identical in design. The axles are equalized throughout, thereby transmitting the load evenly throughout the entire truck. The design is shown on plates 246, 247, 248, and 249.

219. Ammunition Supply System.—The design of the loading gear is shown on plates 250 and 251. It will be seen on the first plate that the projectiles can be picked up from the ground or from a platform at the rear of the carriage by means of a chain hoist carried on an I-beam trolley. The projectile is carried forward and placed on the shot truck, the wheels of which ride on angle iron rails. The shot truck is run forward with as great a velocity as possible until its

buffer strikes the breech of the gun, when the projectile slides on into the powder chamber. The projectile is then rammed by hand. The powder charge is picked up from the rear and placed on the shot truck by means of the same hoist. The shot truck is run forward to the breech of the gun and the charge pushed into the chamber by hand. A speed of firing of seven shots in 14 minutes has been attained in recent tests. In these tests it was necessary to lift the projectiles from the ground. Had the projectiles been located on a platform, level with the working platform of the carriage, it is believed that this time might have been reduced to one shot per minute.

220. MAINTENANCE.—In the service that this one mount has so far seen, it has proved very sturdy and practically no maintenance except the ordinary attention required for the various mechanisms has been necessary. It is believed that no serious difficulty would have been experienced with mount of this design even under the severe conditions prevailing in France during the war.

221. DIFFICULTIES INVOLVED IN SERVICE.—The one feature of this mount which might cause what may be termed difficulties in service, is its emplacement for high angle firing. This emplacement required the full capacity of a 160-ton locomotive crane for installation and removal. To those acquainted with field service of heavy artillery in this war, it is not certain, however, that this constitutes a difficulty that is serious. A heavy locomotive crane was to be included in the equipment of the organization maintaining railway artillery in the park of the Railway Artillery Reserve in France, and since such a crane is required for the ordinary service of maintenance, it would of course, be available for the installation of the equipment of such a gun as this, of which any army would certainly have only a limited number. This emplacement permits of operation at 90 degrees to any existing railway line and it can be installed in less than a day. The platform used with the Navy 14-inch mounts Mark I, and with French 340-millimeter guns and 400-millimeter howitzers required at least two days for installation and the maximum traverse that can be secured in any one position with these mounts is not more than 10 degrees. As a consequence, it is felt that no serious difficulties would be experienced in the service of this mount for land warfare. Trials have proved it particularly easy of service and efficient for coast defense.

222. MERITS.—The merit of this design is that it embodies most of the features found desirable in mounts for large guns during the present war. For a gun of this size, it can be emplaced in a very reasonable time and it can be trained on a target in any direction from any position. It can be operated from a curved track as a sliding mount and has an internal car traversing mechanism. The

speed of operation developed in recent tests of 7 shots in 14 minutes with probability of its reduction to 1 shot per minute is excellent.

223. Demerits.—The only criticism that occurs to the writer in connection with this design is in the matter of the limited elevation to which the gun can be operated either as a sliding or as a fixed emplacement mount. The maximum elevation for operation as a sliding mount is 22 degrees, and 30 degrees for operation as a fixed emplacement mount. The limit for service as either a sliding or fixed emplacement type of mount should be at least as high as 45 degrees and preferably 50 degrees.

Plate 216

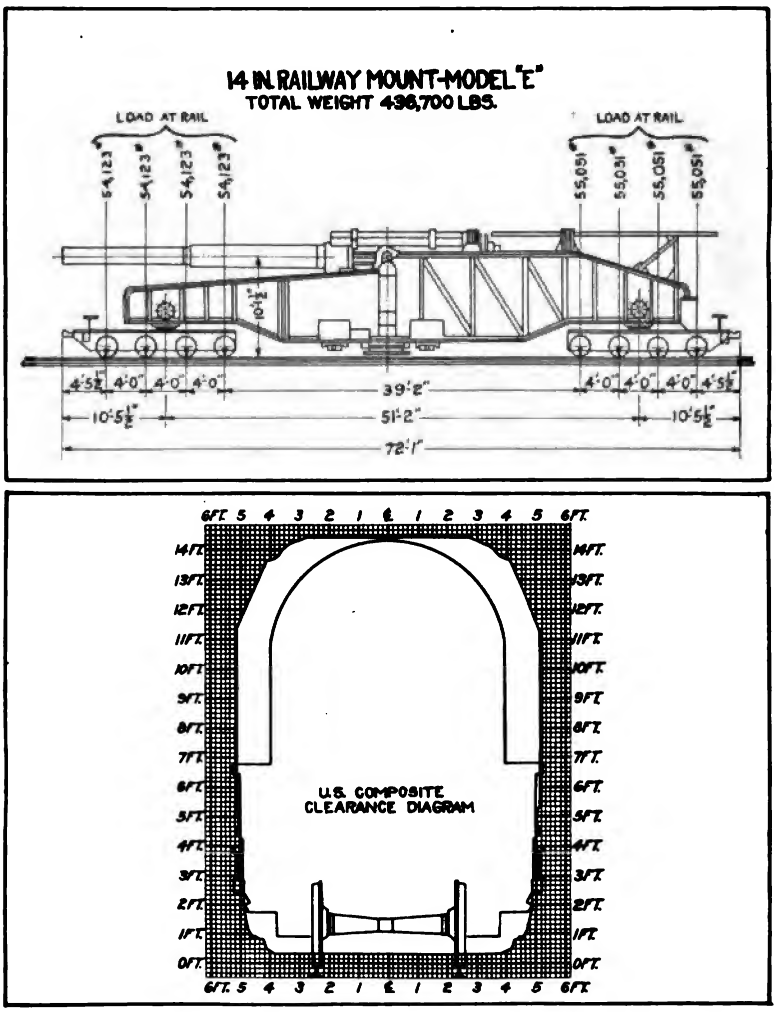


PLATE 217

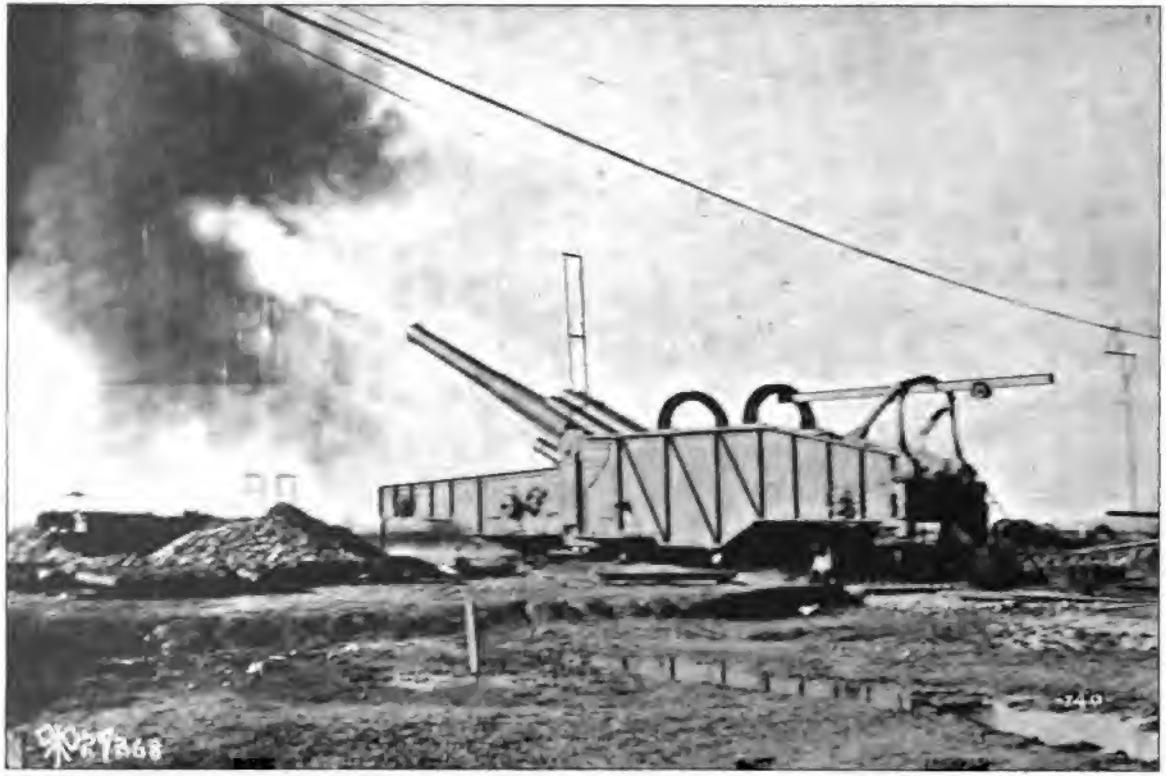
14-INCH, 45-CALIBER AMERICAN GUN ON RAILWAY MOUNT, MODEL "E" (RIGHT SIDE).

PLATE 218

14-INCH, 45-CALIBER AMERICAN GUN ON RAILWAY MOUNT, MODEL "E" (LEFT SIDE).

14-INCH, 45-CALIBER AMERICAN GUN ON RAILWAY MOUNT, MODEL "E" (LEFT SIDE).

PLATE 220



14-INCH, 45-CALIBER AMERICAN GUN ON RAILWAY MOUNT, MODEL "E" (FIRING).

PLATE 221

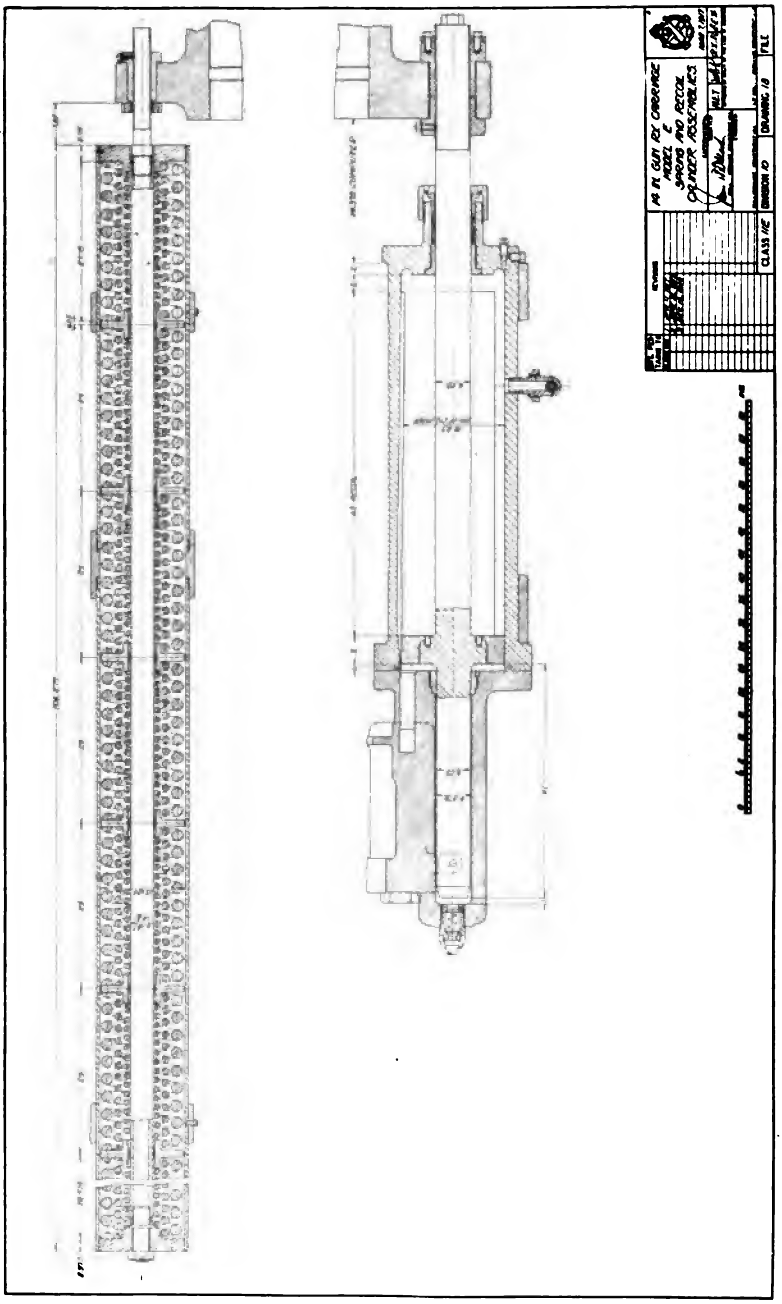

14 IN. GUN FIX CARRIAGE
MODEL E
SPRING AND RECOIL
CYLINDER ASSEMBLIES
CLASS 14E
DIVISION 10
DRAWING 18
FILE

PLATE 222

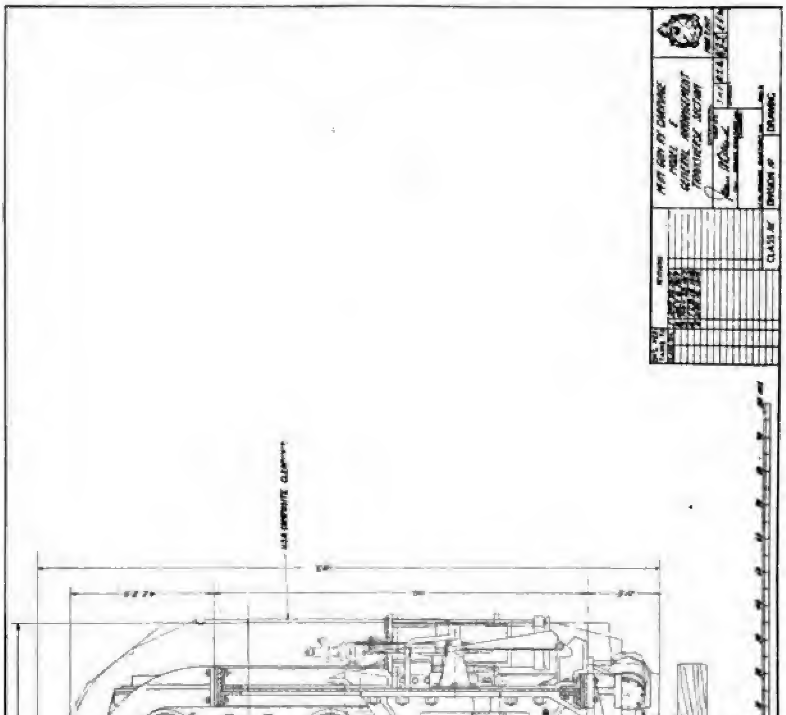


PLATE 223

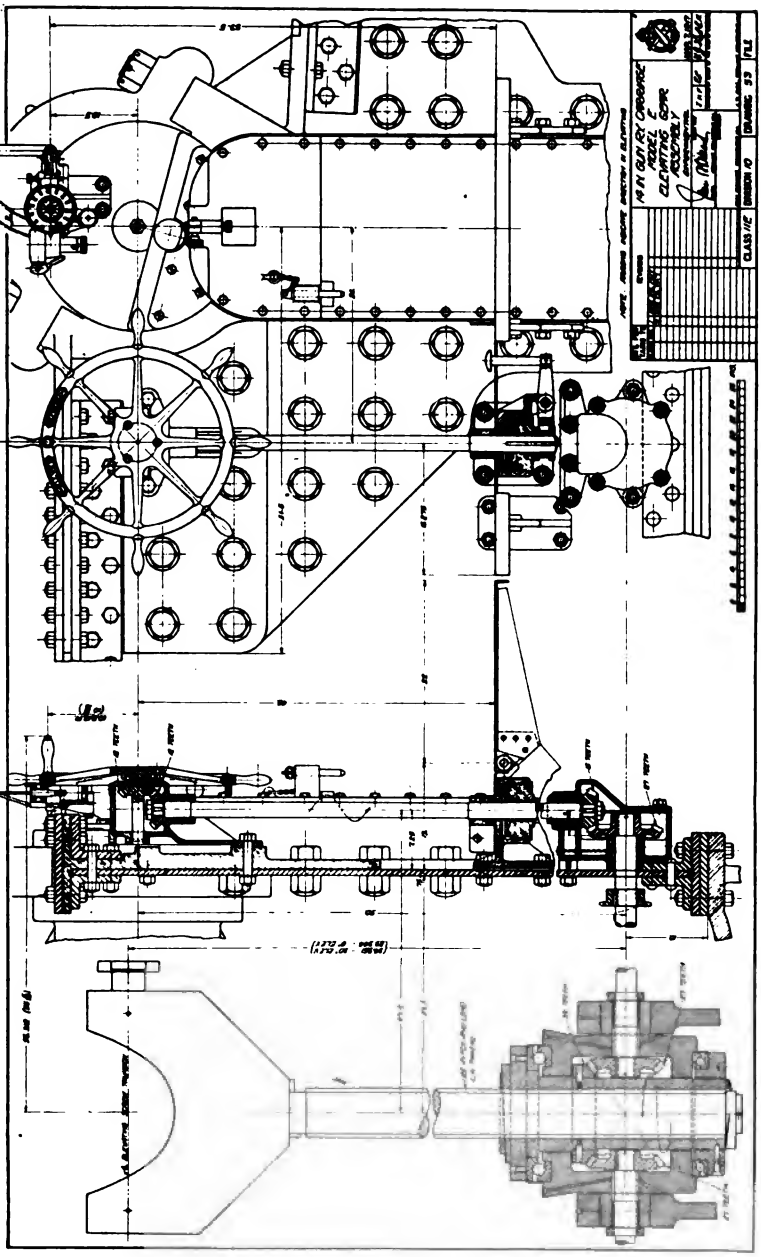


PLATE 224

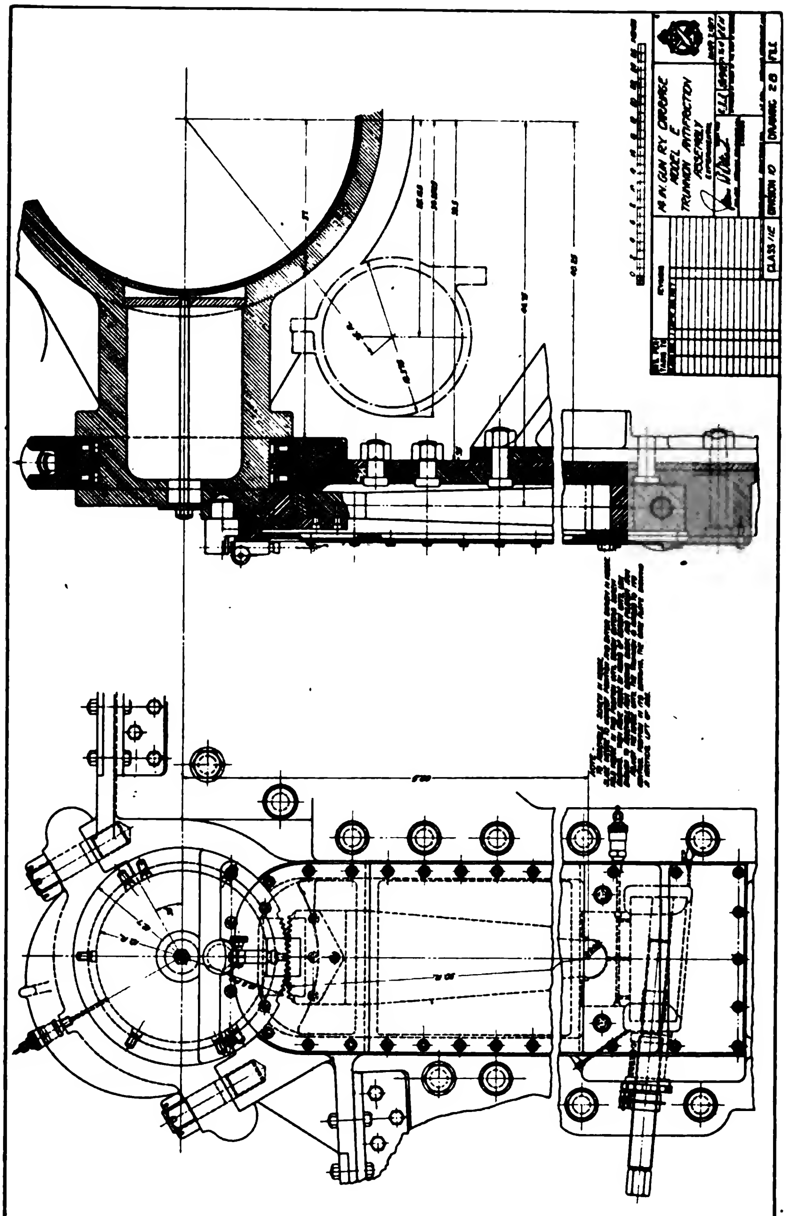

14 IN. GUN RY CARRIAGE
MODEL E
TRUNNION ANTIFRICTION
ASSEMBLY
CLASS 11E
DIVISION 10
DRAWING 20
FILE

Plate 225

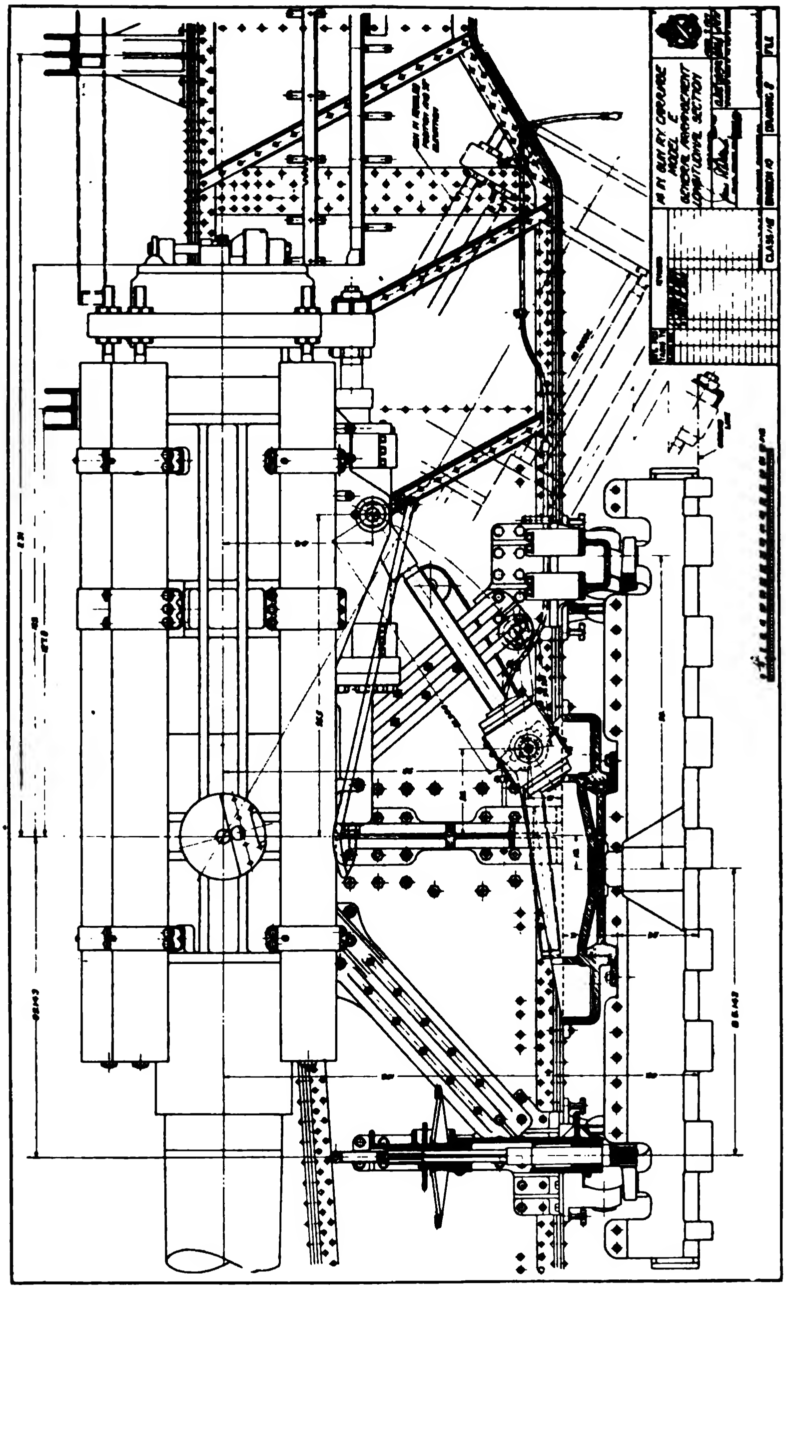


PLATE 226

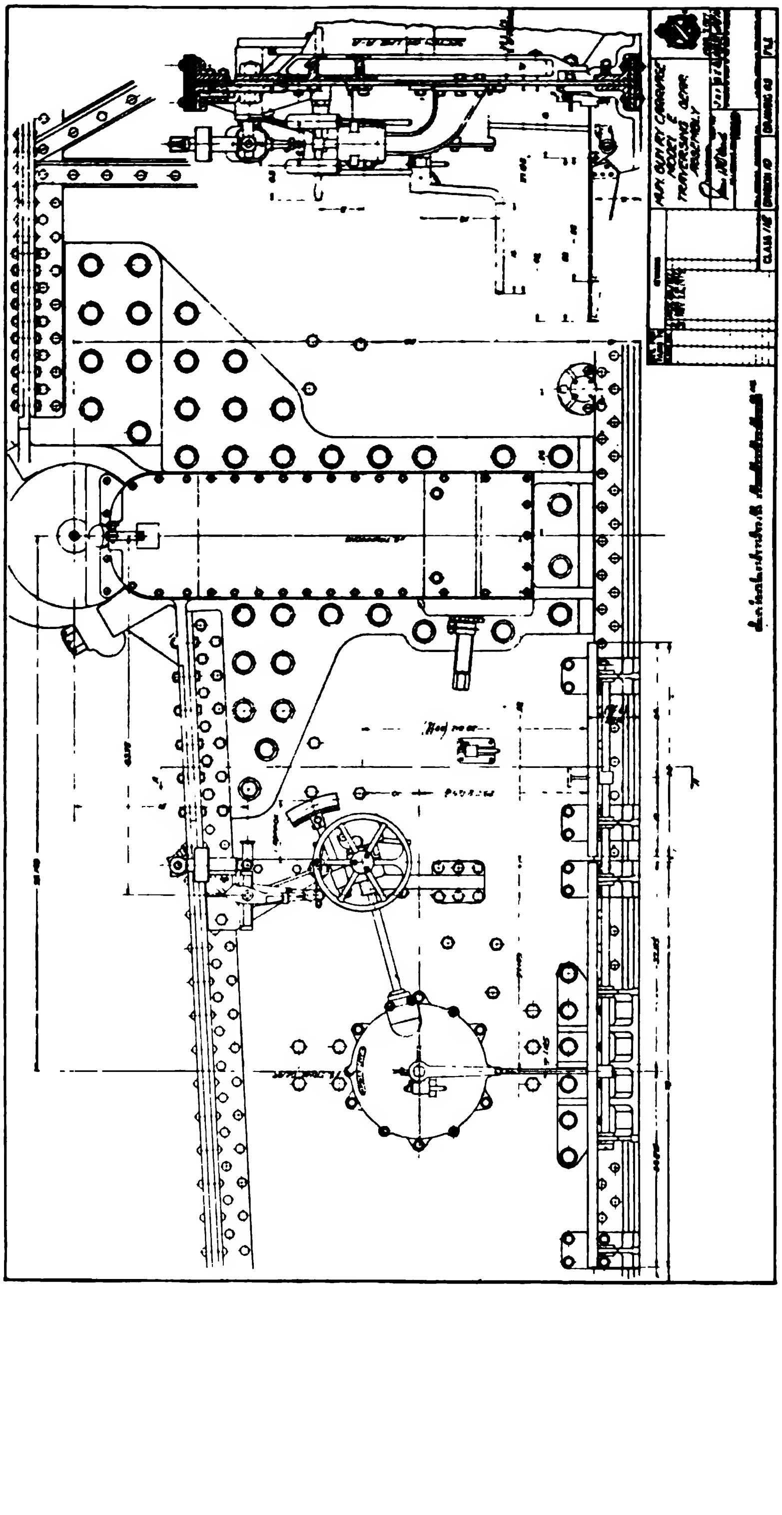


PLATE 227

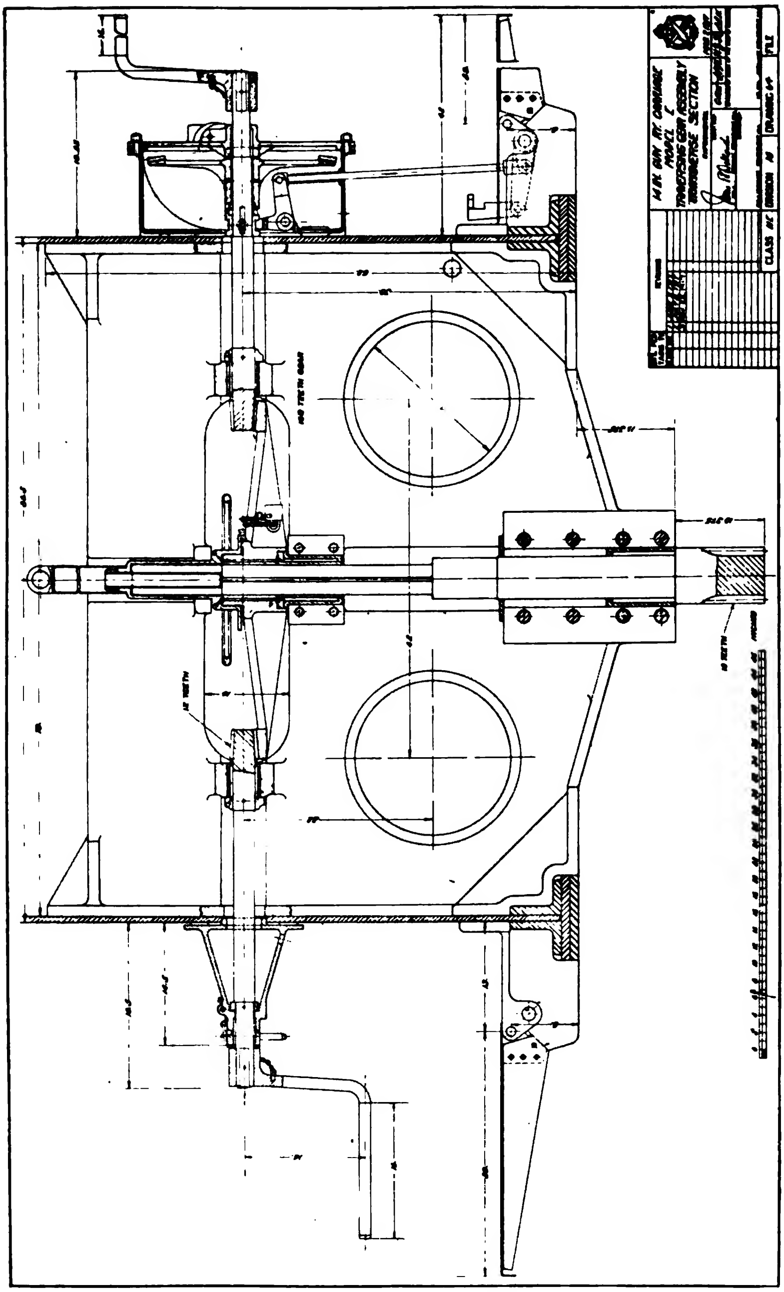


Plate 228

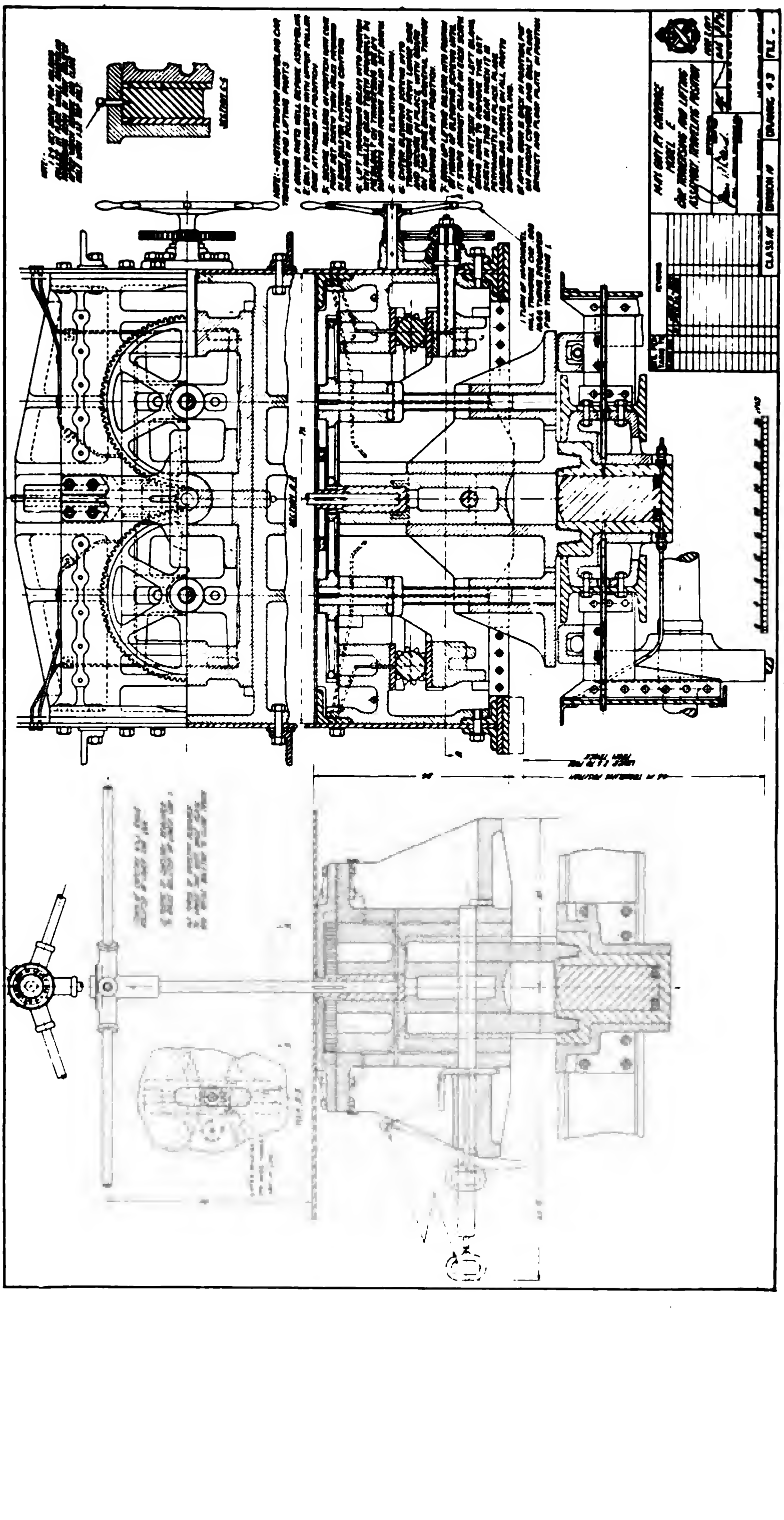


PLATE 229

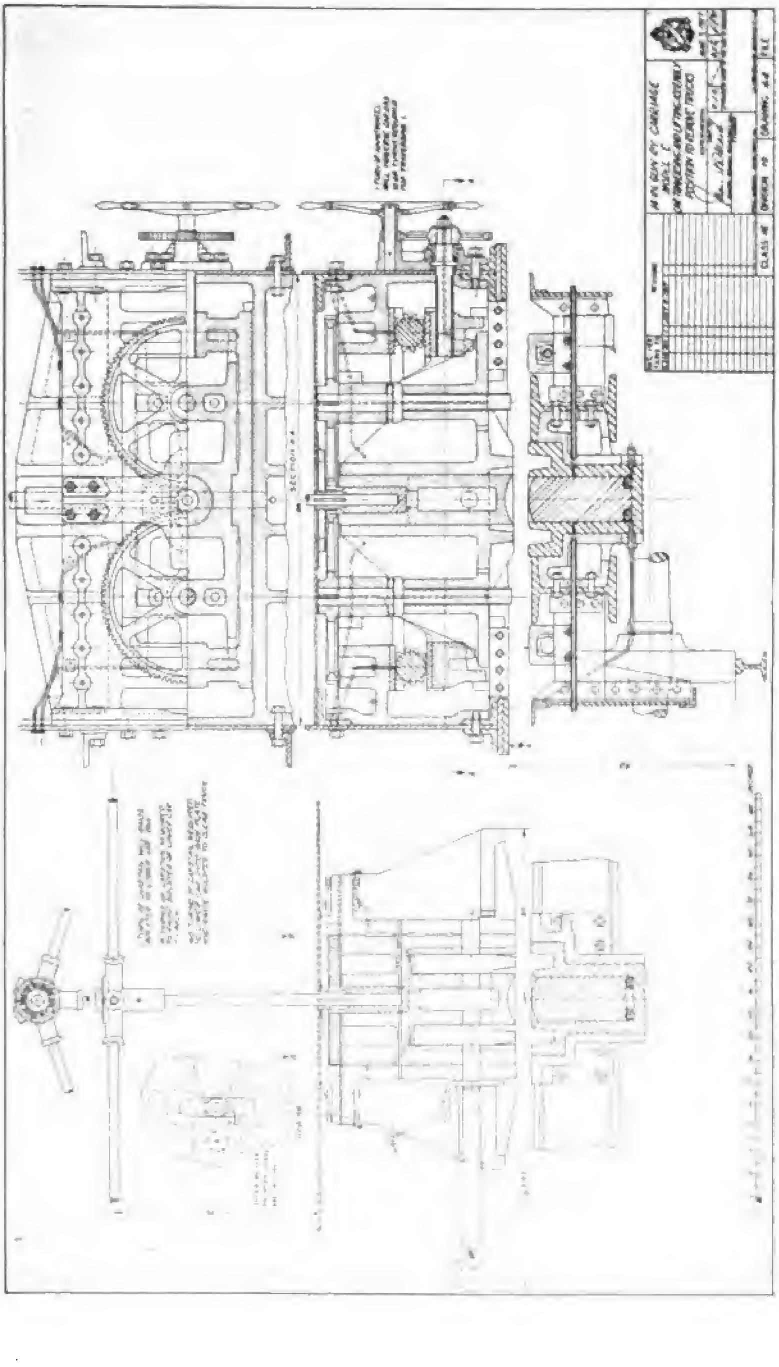


PLATE 230

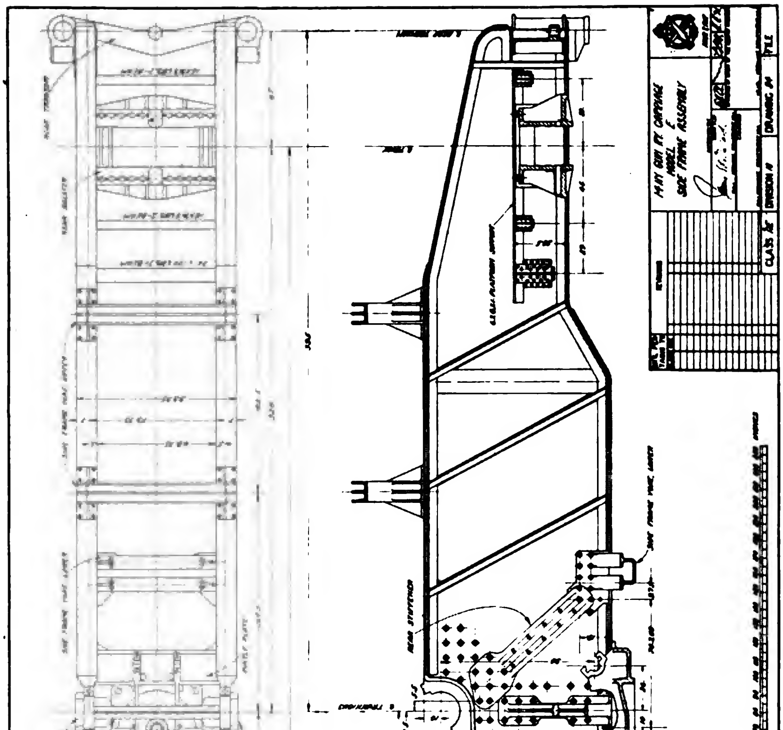
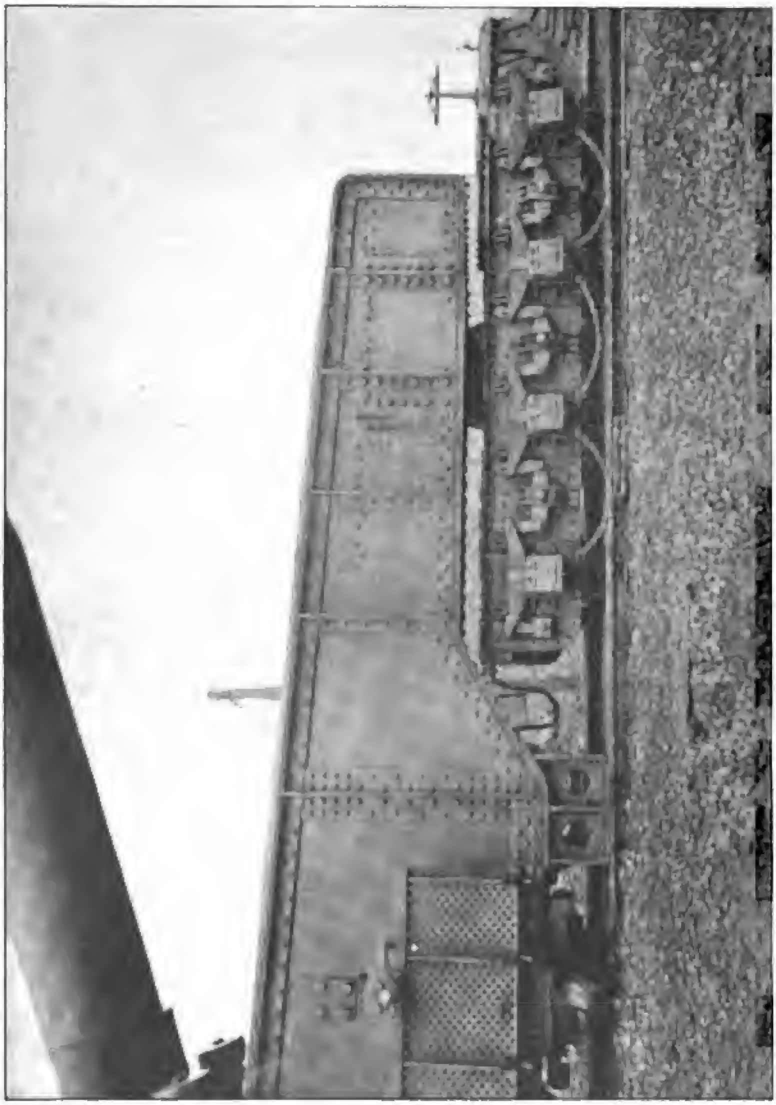


PLATE 231

STEEL SLIDE SHOES (FRONT) OF THE 14-INCH, 45-CALIBER AMERICAN GUN MOUNT, MODEL "E."

PLATE 232



STEEL SLIDE SHOES (REAR) OF THE 14-INCH, 45-CALIBER AMERICAN GUN MOUNT, MODEL "E."

Plate 233

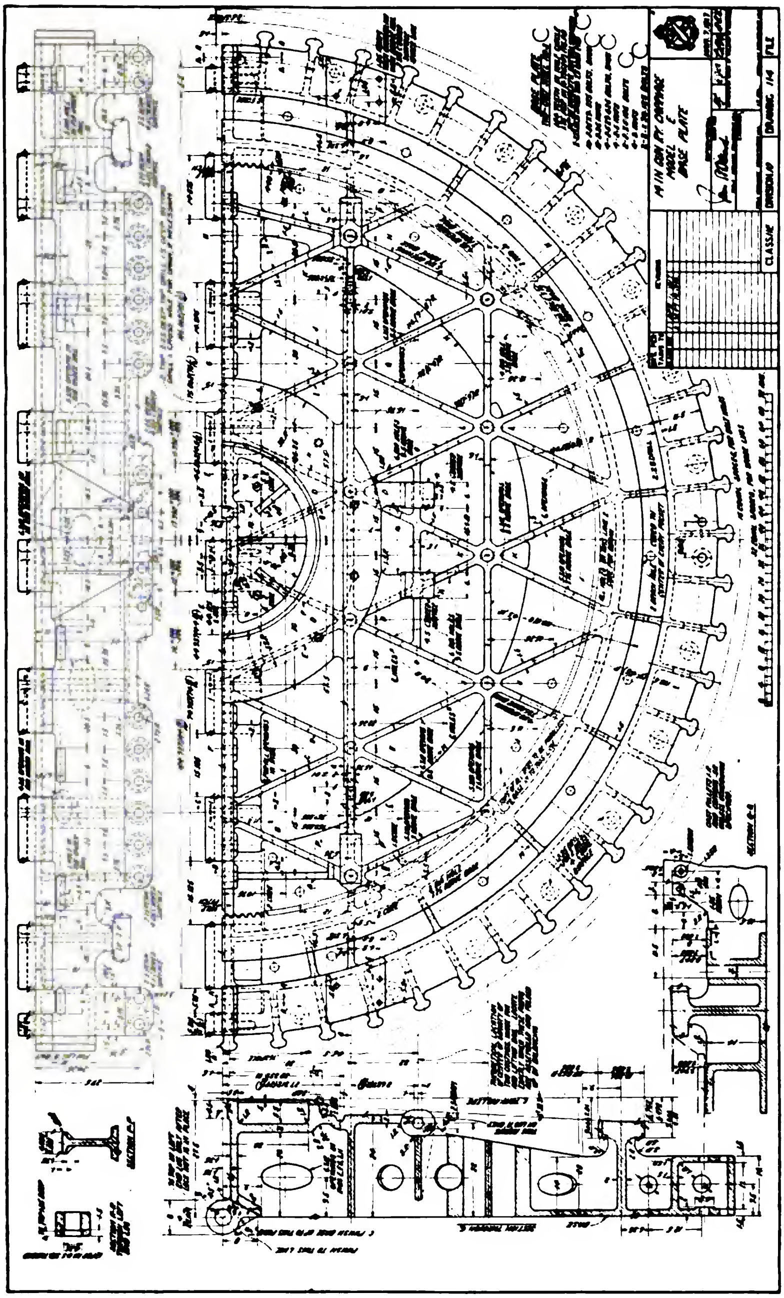
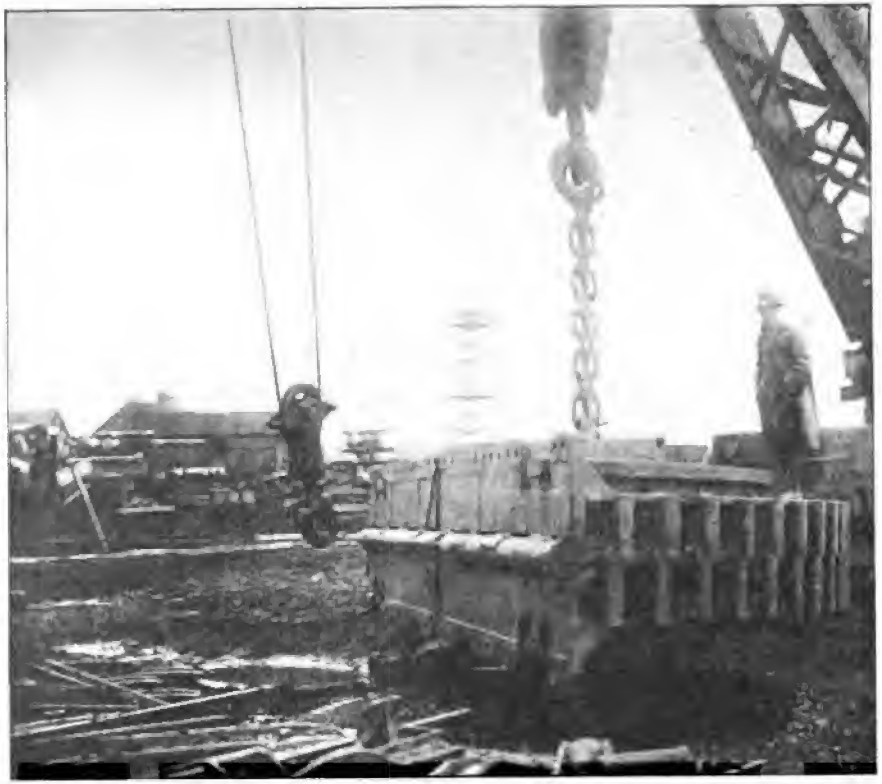


PLATE 234

BASE RING OF THE 14-INCH, 45-CALIBER AMERICAN GUN MOUNT, MODEL "E."

PLATE 235



BASE RING OF THE 14-INCH, 45-CALIBER AMERICAN GUN MOUNT, MODEL "E" (FIRST STEP OF INSTALLATION).

PLATE 236

BASE RING OF THE 14-INCH, 45-CALIBER AMERICAN GUN MOUNT, MODEL "E" (SECOND STEP OF INSTALLATION).

PLATE 237

BASE RING OF THE 14-INCH, 45-CALIBER AMERICAN GUN MOUNT, MODEL "E" (THIRD STEP OF INSTALLATION).

BASE RING OF THE 14-INCH, 45-CALIBER AMERICAN GUN MOUNT, MODEL "E" (FOURTH STEP OF INSTALLATION).

PLATE 230

BASE RING OF THE 14-INCH, 45-CALIBER AMERICAN GUN MOUNT, MODEL "E" (FIFTH AND LAST STEP OF INSTALLATION).

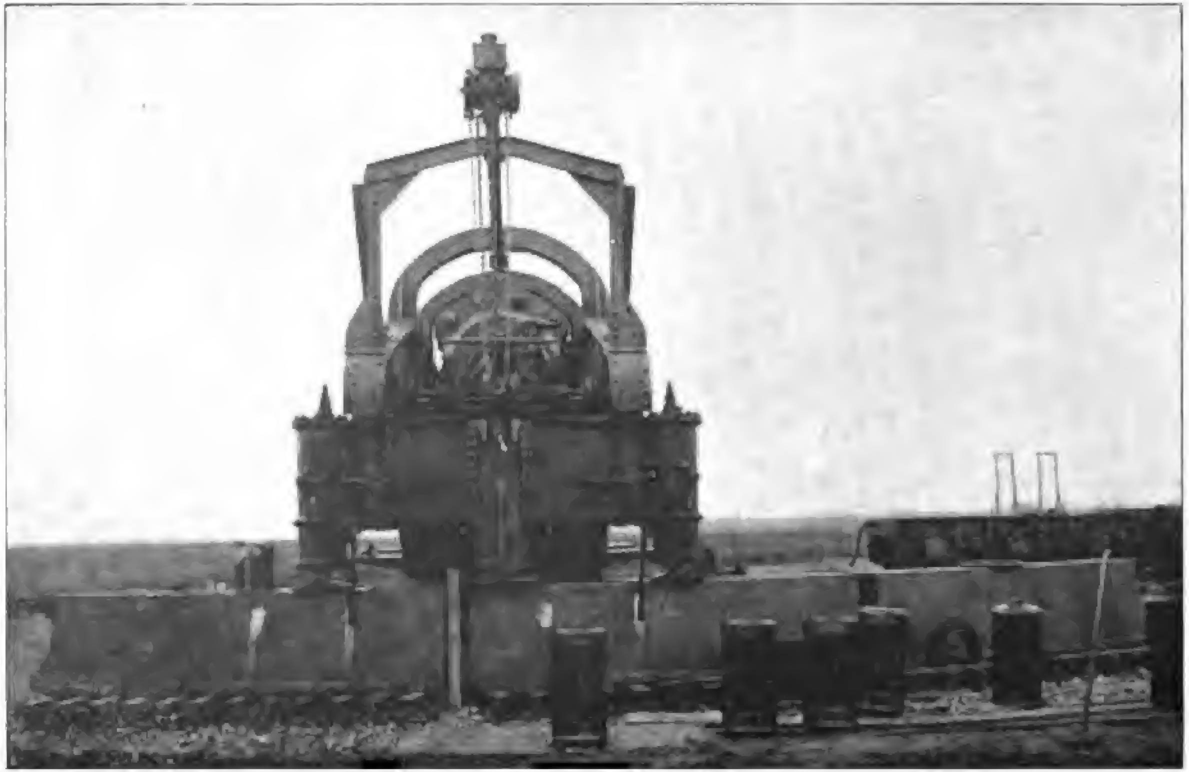
PLATE 240

14-INCH, 45-CALIBER AMERICAN GUN MOUNT, MODEL "E," INSTALLED ON BASE RING FOR ACTION.

PLATE 241

14-INCH, 45-CALIBER AMERICAN GUN MOUNT, MODEL "E," INSTALLED ON BASE RING FOR ACTION. (NOTE TRACKS.)

PLATE 242



SUPPORT BEAM FOR THE REAR OF THE 14-INCH, 45-CALIBER AMERICAN GUN MOUNT, MODEL "E."

PLATE 243

SUPPORT BEAM AND SUPPORTING MECHANISM OF THE 14-INCH ,45-CALIBER AMERICAN GUN MOUNT, MODEL "E."

PLATE 244

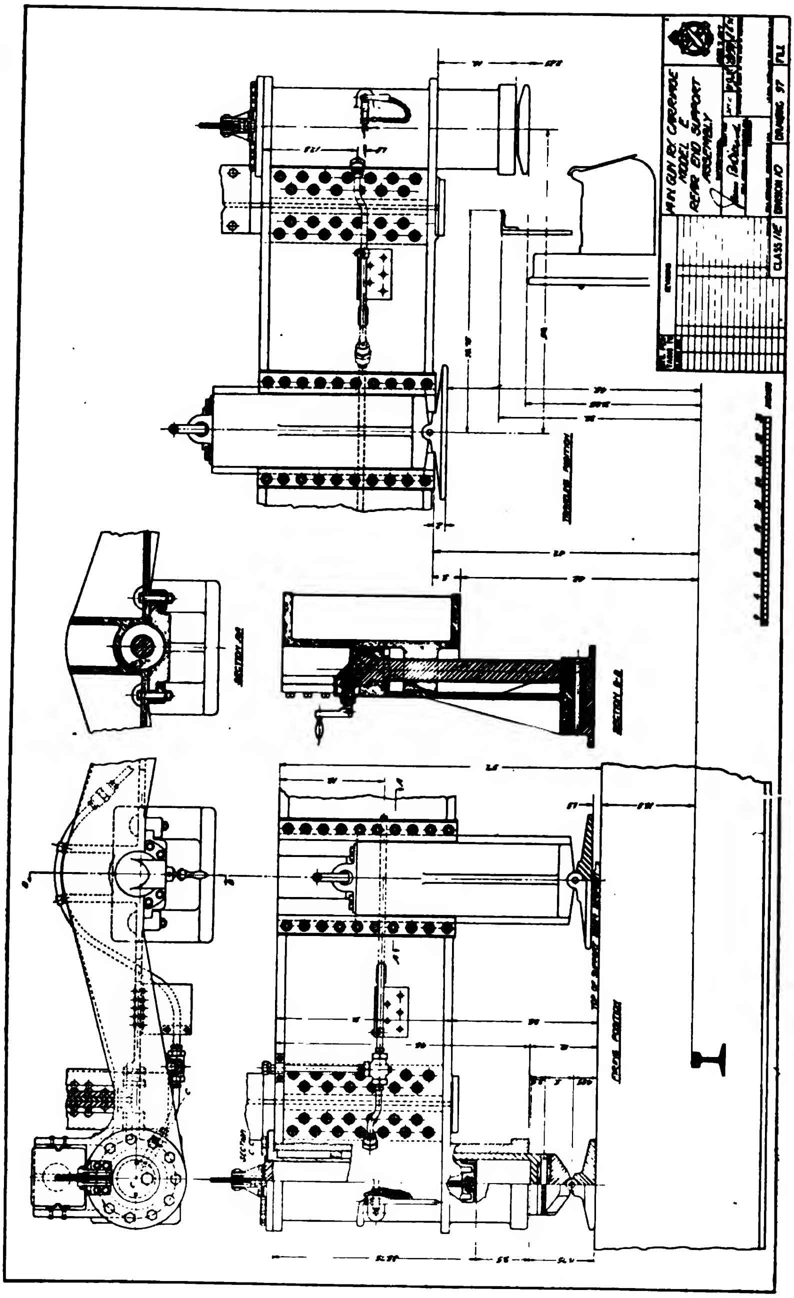


PLATE 245

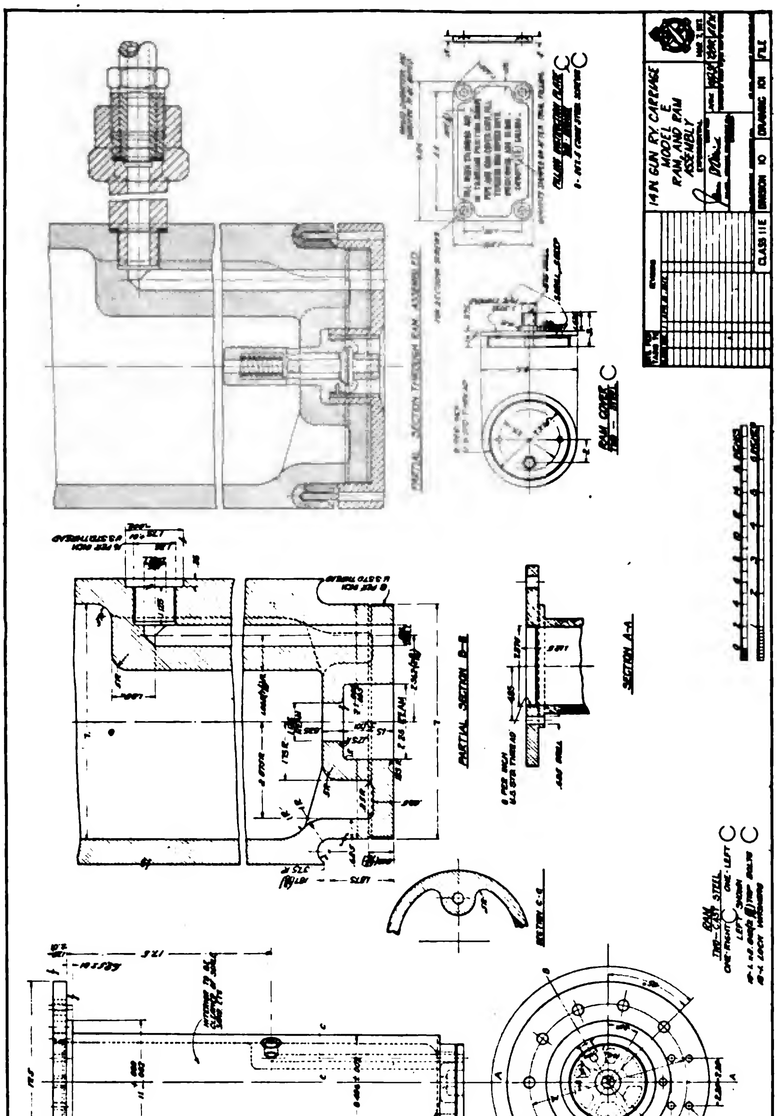

14 IN GUN RY. CARRIAGE
MODEL E
RAM AND RAM ASSEMBLY
PARTIAL SECTION B-B
SECTION A-A
SECTION C-C
RAM COVER
CLASS 11E
DIVISION 10

PLATE 246

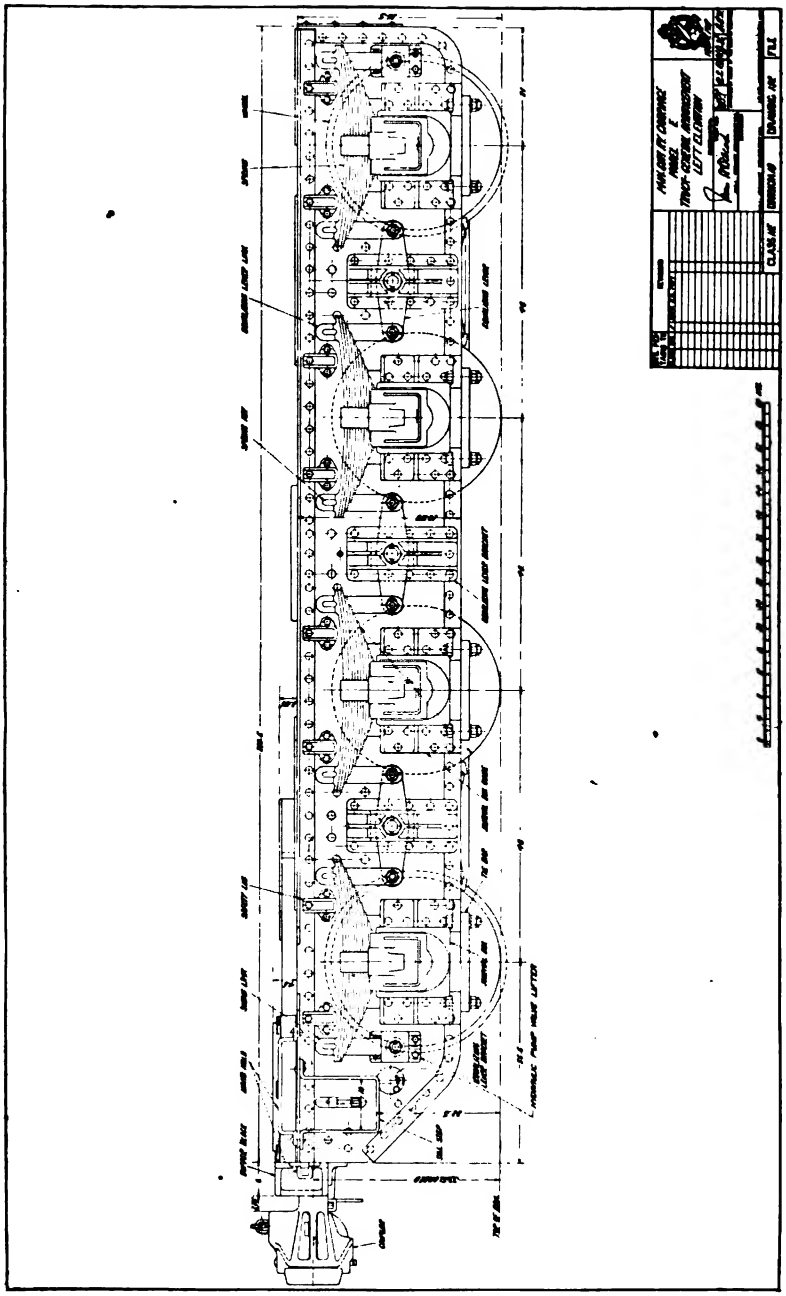


PLATE 247

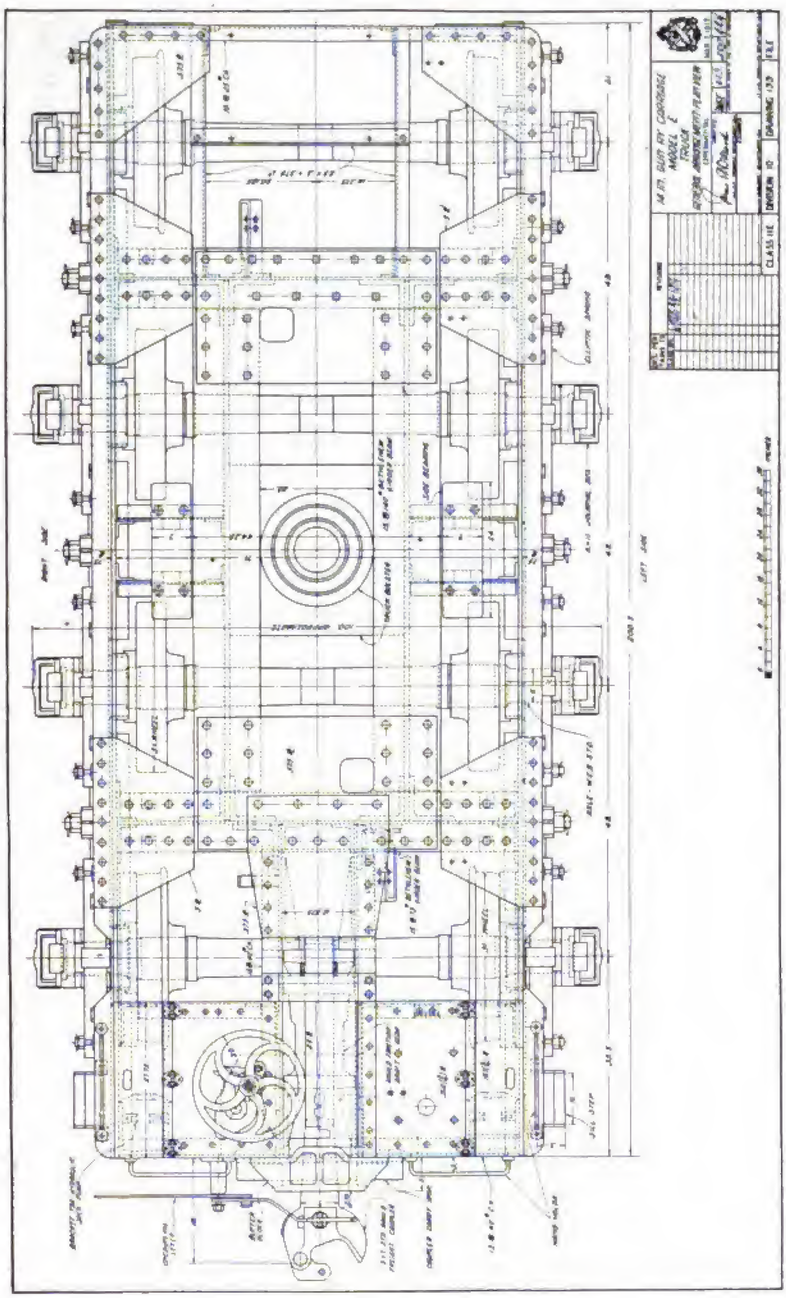


PLATE 248

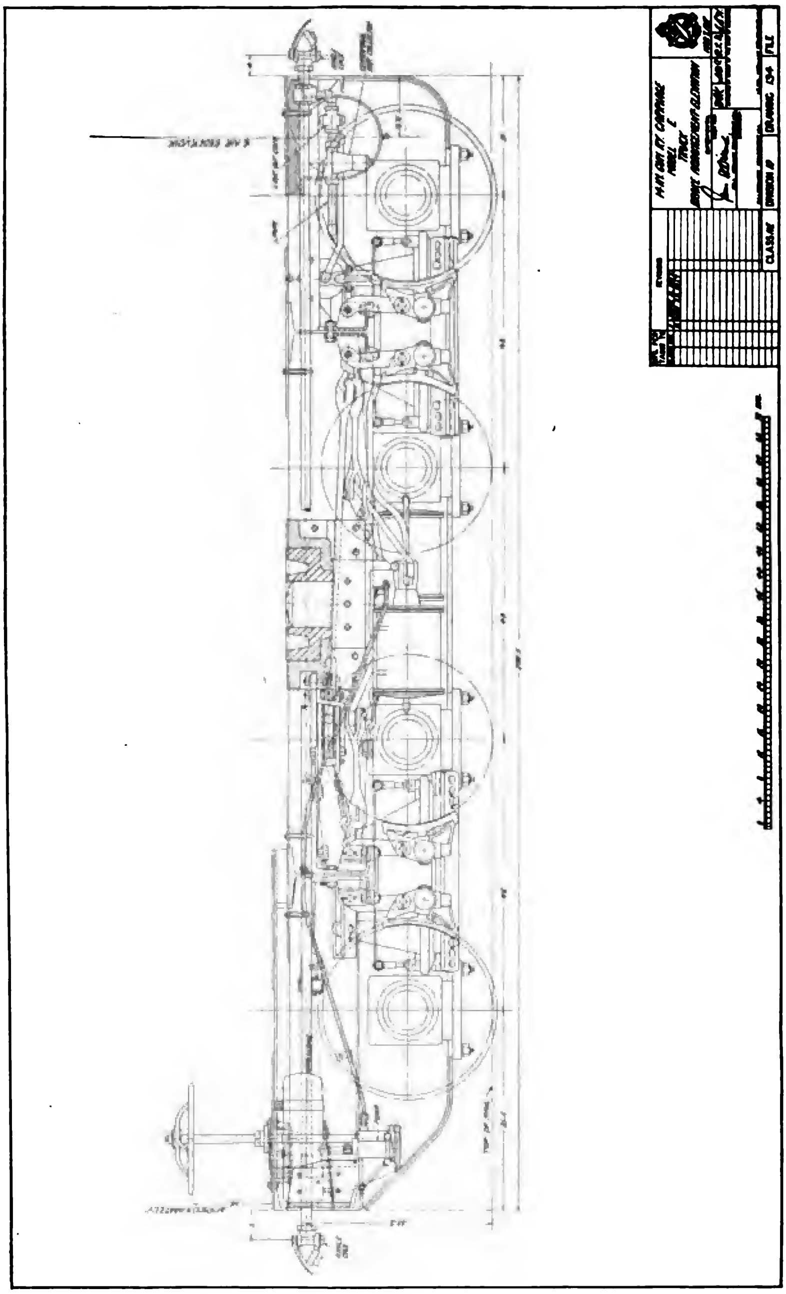


PLATE 249

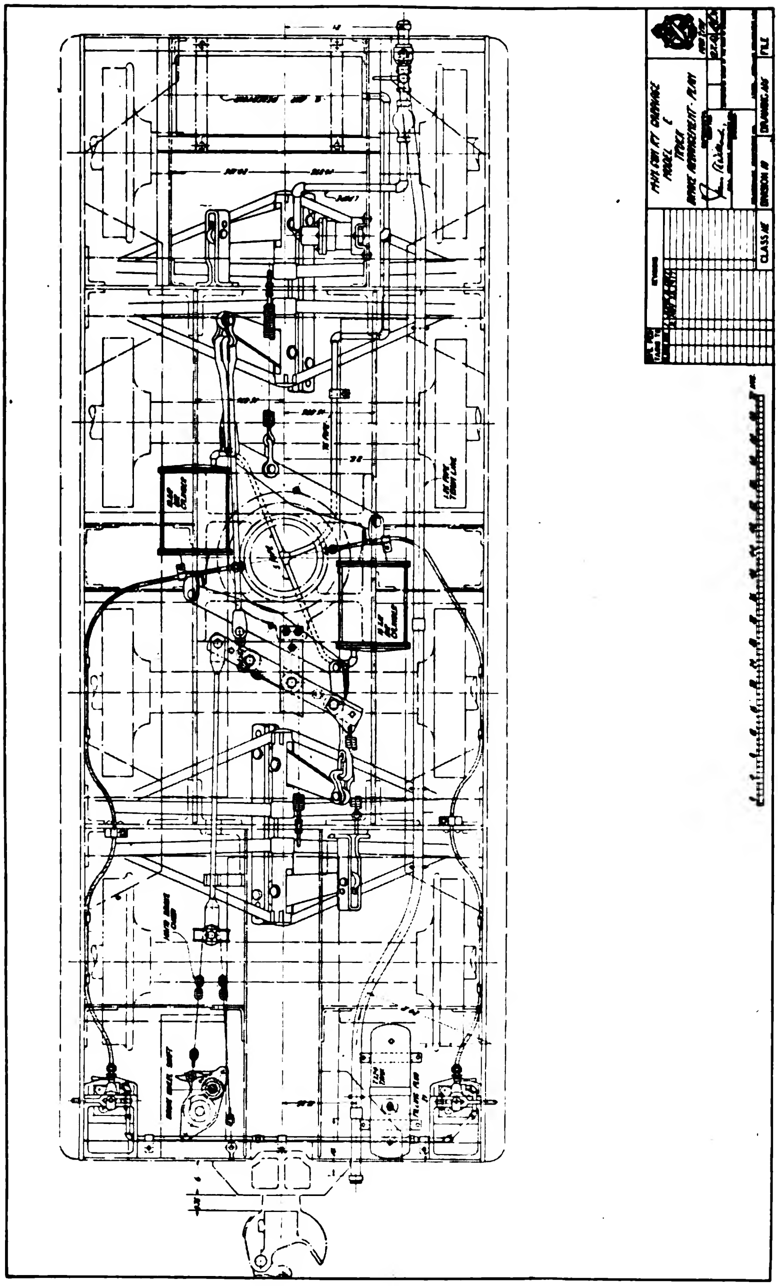


Plate 250

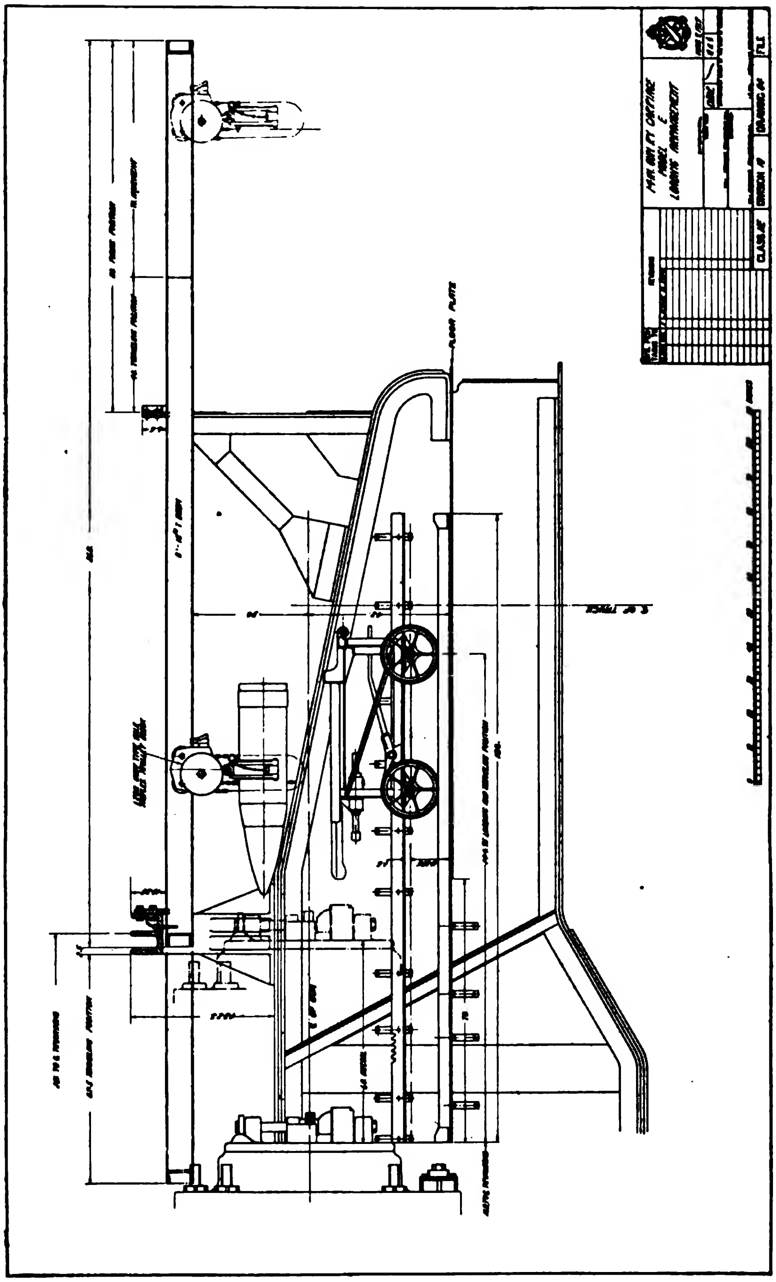
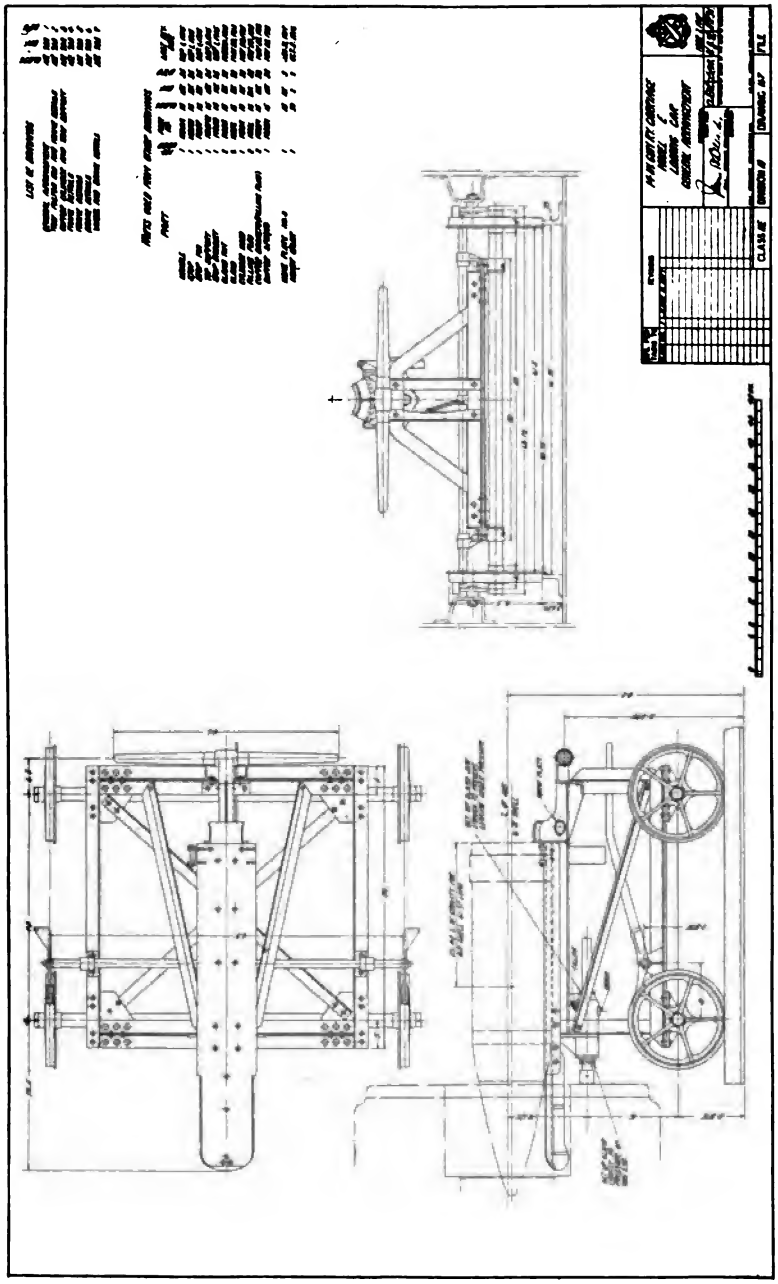


PLATE 251



10.—AMERICAN 14-INCH GUN, NAVAL RAILWAY MOUNT, MARK I. (23)

224. This mount is of the cradle recoil car traverse type. The gun is mounted in a cradle having combined hydrospring and hydropneumatic recoil mechanism. This cradle is supported in turn by its trunnions on two cast-steel deck lugs, similar to those used in the turret of the battleship, which are attached to the side girders of the carriage. The structural steel carriage is carried on two structural steel span bolsters which in turn rest on two 3-axle trucks each. The mount fires from its trucks at elevations between 10 and 15 degrees. When fired from its trucks it is possible to traverse the mount only by operating it on a curved track. At elevations between 15 and 45 degrees it is necessary to remove the trucks and operate the mount on a fixed emplacement. When operated on a fixed emplacement the internal car traversing mechanism is used to train the gun in azimuth. General views are shown on plates 253 to 263.

225. The guns used on these mounts are 14-inch naval rifles, Mark IV, Modification 1, of 50-caliber length. The gun is made up of 10 main parts, including a tube jacket, hoops, breech bushing, and locking rings. The rifling has a right hand twist increasing in pitch from one turn in 50 calibers at the origin, to one turn in 32 calibers at a distance of 574 inches from the origin. From this point to the muzzle the twist is uniform; that is, one turn in 32 calibers. Holes are drilled in the breech recess pointing toward the center of the powder chamber to admit air for ejecting the gases from the gun. The gas ejector valve is attached to the breech face of the gun, plate 256. The gun is provided with a breechblock of the Welin or stepped screw type and DeBange system of gas check. The breech recess is threaded and slotted into 16 sectors, one blank and three thread sectors being included in each of four groups, and only one-sixteenth of a revolution of the block is required to release or lock it. The block when rotated falls open by its own weight, dropping at an angle of 16 degrees to the right of a vertical line through the center of the bore and is checked by a combined spring and air buffer, shown at the bottom of the breech lug, plate 256, and shown in detail on plate 257. The breech is closed by air pressure admitted into the combined buffer and closing cylinder. The breechblock is fitted with a mechanical firing mechanism of the design shown on plate 258.

226. Recoil Mechanism.—The recoil mechanism consists of one recoil and four spring cylinders arranged about the cradle and of a design shown on plate 259. The recoil cylinder is the usual hydraulic brake, but uses throttling rods, three in number, instead of grooves or bars. The spring tubes each contain double spring columns, plate 267, divided into six sections and the ends of the spring rods are provided with air-tight pistons so that compressed air can be used to aid in returning the piece to battery at high elevations. When the

gun is being fired at elevations between 10 and 15 degrees, the mount recoils along the track a distance of from 30 to 40 feet. Under such circumstances the mount is returned to its firing position by a winch mounted on the front span bolster. The maximum length of recoil at the maximum elevation is 44.5 inches. When operated at elevations between 15 and 45 degrees, it is necessary to place the mount on a fixed emplacement which includes a pit to receive the breech of the gun at high elevations and into which the gun may recoil. The recoil and recuperator pistons are all attached to a yoke which is slipped over the breech of the gun from the rear and is secured to a collar on the gun, by means of a bronze locking ring.

227. Elevating Mechanism.—Elevation from 0 to 45 degrees is secured through a heavy screw hinged to the cradle at the breech end and working in a nut carried in an oscillating bearing at the center of the girder. This nut is rotated from a handwheel on the side of the mount by means of three sets of mite gears and intermediate shafting, plates 268 and 269. One revolution of the handwheel moves the gun through about 20 minutes in elevation. The elevating mechanism includes antifriction devices of the design shown on plate 270. It was mentioned under the head of Elevating Mechanism in the description of the 14-inch railway mount, model E, that the antifriction device of that mount is practically identical with that used on the Navy mounts. This mechanism works efficiently in reducing the trunnion friction, but as mentioned before, does not embody those flexible elements which permit the shock of recoil to be transmitted directly into the trunnion bearings without excessive strain on the antifriction mechanism.

228. Traversing Mechanism.—When the gun is fired at low elevations from the wheels, traverse is secured by moving the mount along a curved track by means of a small winch located on the front bolster. When the gun is to be fired at high elevations from the emplacement the latter is so placed as to give the gun approximately the correct azimuth. Small changes in azimuth are effected by traversing the mount on the jacks and jacking beams which support it, and around the pintle of the emplacement, by means of a screw located on the rear beam. A traverse of 2.5 degrees on each side of the center line can be secured with the jacking beams in any one position. It will be observed on plate 23 that when the gun is operated at high elevations, the carriage is supported on four hydraulic jacks placed under the ends of the two jacking beams. If it is desired to secure more than the total of 5 degrees traverse on one emplacement, the jacks can be lowered and the beams run to the extreme limit in the direction in which it is desired to traverse each end of the mount, and the jacks moved until they are in their proper position under the ends of the beams. By this procedure it is possible to secure a total traverse of about 10 degrees on one emplace-

ment. It would of course be possible to move the jack supports and secure greater traverse, but the emplacement is not so constructed as to take safely the shock of recoil at any very great side angle. The details of construction of the rear jacking beam with its traversing screw are shown on plate 271.

229. Gun Carriage.—The gun carriage is incorporated in the car body and the two are described together in the next paragraph.

230. Car Body.—The car body, plate 253, consists of two heavy single web structural steel girders connected by structural and cast steel transoms. The cradle is swung by means of its trunnions in the bearings of the deck lugs attached to the side girders. The elevating and traversing mechanisms already described, are likewise assembled to the girders. A bullet proof cab of 0.25 inch steel is constructed over the rear of the girders to shelter the personnel. This is the only mount that the writer has observed that is so heavily protected with armor. The Italian 38-centimeter railway mount has a shelter of armor plate over the working platform, but no side plates.

231. Anchorage.—When the gun is operated at elevations between 10 and 15 degrees, no anchorage other than wheel friction is required. For operating at high elevations a pit is dug, a bed of timbers is provided at each end of the car body and the weight of the car is transferred to these beds by hydraulic jacks placed between them and special jacking beams incorporated in the car body. The pit is about 9 feet deep, plate 272, and is lined with timbers. The timbers at the rear end of the pit are united into a mat or spade and are connected to the pintle near the center of the girders of the mount, by structural members and a trunnion bed plate casting so that the horizontal component of the shock of firing is taken against them. On plate 273 the emplacement is shown complete and ready to receive the mount. This firing platform is similar in general design to that required for the 340-millimeter French gun and the 400-millimeter French howitzer railway mounts, and for the American 16-inch howitzer when operating at its maximum elevation. The braces between the cast steel pintle block and the timber mat or spade in the pit for the three mounts just mentioned, are made up of 14-inch square timbers. The braces for this mount are built up of structural steel.

232. Trucks.—The four trucks are identical in construction and are 6-wheel locomotive type with 9 by 12-inch journals and 36-inch wheels. Each truck is provided with hand brakes. The details of construction are shown on plate 274. These trucks are connected in pairs by structural steel span bolsters and the ends of the main girders pivot on these span bolsters.

233. Ammunition Supply System.—For the service of ammunition an I-beam trolley track is so arranged along the roof of the cab of the

mount, plate 253, that it can be pushed to the rear and made continuous with a similar track in the ammunition car, plate 275, which is coupled just behind. The shell is picked up in the ammunition car by a trolley hoist, run along into the cab of the mount and let down onto the ammunition tray, plate 276. This tray runs on wheels along a track to the breech of the gun. It is provided with a buffer which brings it to a stop when it hits the breech and the shell continues on into the chamber of the gun and is arranged by hand. The gun is loaded at 0 degrees elevation.

234. MAINTENANCE.—Two serious defects in the design of this mount result in considerable difficulties in maintenance. First, the axle loads, especially on the front trucks, are so great as to make it practically impossible to transport the mounts for any great distance at a speed greater than from 5 to 10 miles an hour without more bearing trouble than is normally expected and certainly without more than can be tolerated in a mount carrying a gun of this value. Second, the structural steel members which connect the spade and the trunnion bed plate are so flexible as to give trouble in handling. They are inclined to buckle easily. An additional difficulty was encountered as a result of covering the entire working platform with armor. A great amount of moisture condenses on all metal surfaces within the cab and does not evaporate very rapidly because of the lack of circulation of air. This condition makes it necessary to pay a great amount of attention to all of the unpainted metal surfaces.

235. DIFFICULTIES INVOLVED IN SERVICE.—The winch that was supplied on the mount as originally designed is not powerful enough to move the mount along the track. It will be necessary to provide a more powerful winch for the operation of the mount at elevations under 15 degrees. The trunnion bed plate casting is very heavy, and difficulties were encountered in installing the emplacement with the special crane that was provided. It is probable that the casting is heavier than it need be, and it is likewise probable that the crane provided was not as powerful as it should be. The type of emplacement required for the operation of this gun at high elevation has always been considered objectionable because of the excessive time required for its installation. The platforms used by the French guns required from two to five days for installation and usually two days for removal. This platform can be installed a little more quickly, but from two to three days is a fair average. The use of this type of emplacement, of course, requires a special crane car or locomotive crane and the total battery equipment is unusually large.

236. MERITS.—In speaking of this carriage from the broadest standpoint it can not be said to have many merits. It can be fired without any track preparation up to an angle of 15 degrees, but it would be criminal to fire a gun of this type at any such angle except in an ex-

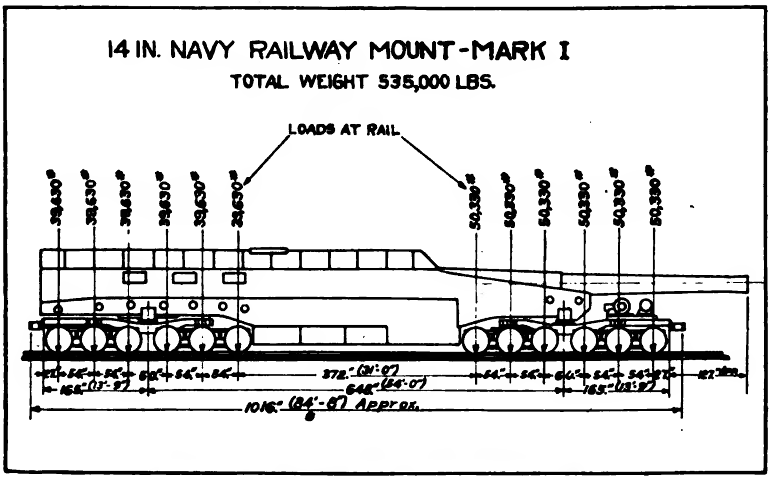
treme emergency. The loading mechanism is excellent in that it is simple and is operated entirely by hand.

237. DEMERITS.—It should be understood in dealing with this carriage that it is a carriage produced purely for the emergency and may be classed with what the French call "Affuts de Circonstance." When fired at an angle above 15 degrees it requires the same cumbersome firing platform that is used with the French 340-millimeter gun and 400-millimeter howitzer. The carriage is supported on two six-axle trucks, and the axle load on the front truck is so great as to cause considerable trouble with overheated journals and bearings. Considerable difficulty was experienced in securing permission to move this mount over French railways because the axle loads of the front truck exceeded by 13,000 pounds the permissible axle load for French railways. It seems quite certain that nothing but the desperate need for guns for this range and caliber could have secured the necessary permission to move them about. The axle load on the front truck is approximately 53,000 pounds. The maximum permissible axle load on French railways is approximately 39,000 pounds. It is understood that an axle load of 62,000 pounds is permissible on main lines in America. It seems quite certain, however, that serious difficulty would be experienced in moving these mounts over newly constructed lines laid over areas that had been badly shell torn. Fortunately it was not necessary to move the mounts on any lines except those that were on fairly settled ground.

238. In moving the five carriages of this type, which were operated by Navy personnel, from St. Nazaire to Camp Mailly, all of them but one developed serious difficulty with overheated journals, and the one that escaped this difficulty was run at an average speed of 5 miles an hour. In returning one of the mounts from Camp Mailly to Bordeaux for return to America, it was necessary to put it in the French shops three times to repair damages to overheated journals and bearings. It would seem possible to limit this difficulty by providing all of the bearings with hard grease cellars such as are used on large locomotives. This would provide a positive oiling system that probably would make it possible to operate the mounts already constructed with less difficulty. The armor-plate cab is probably more of a nuisance than an advantage. While the mounts were being operated against the railway yards of Montmedy and Longuyon from the vicinity of Verdun, the Germans located the battery positions. Some shells burst very close to the mounts. One of these bursts would have resulted in a number of casualties had the mount not been equipped with armor. This is one of the few cases on record in which the enemy were able to locate the railway positions accurately and fire on them with any effect. None of the heavy gun mounts in the French and British Armies were provided with any such armor and

apparently they never felt the need for them. As noted before, this steel cab gave considerable difficulty from the condensation of moisture on all metal surfaces within it, and it is felt that the chance case in which the enemy was able to locate the position does not warrant the providing of armor. The Italian 38-centimeter railway mount has an armor-plate roof over the working platform to protect the personnel from machine gun fire from air planes. The German 28, 24, and 21 centimeter guns were likewise provided with light armor, but it is felt that excessive use of heavy shelters, concrete as well as steel, by the Germans indicates rather a tendency toward proved needless and foolish precautions and should not be considered an example that is to be followed.

PLATE 252



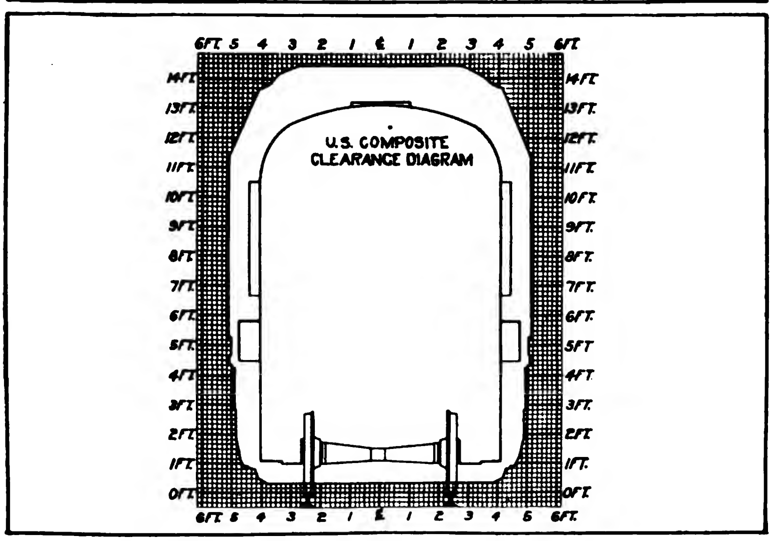
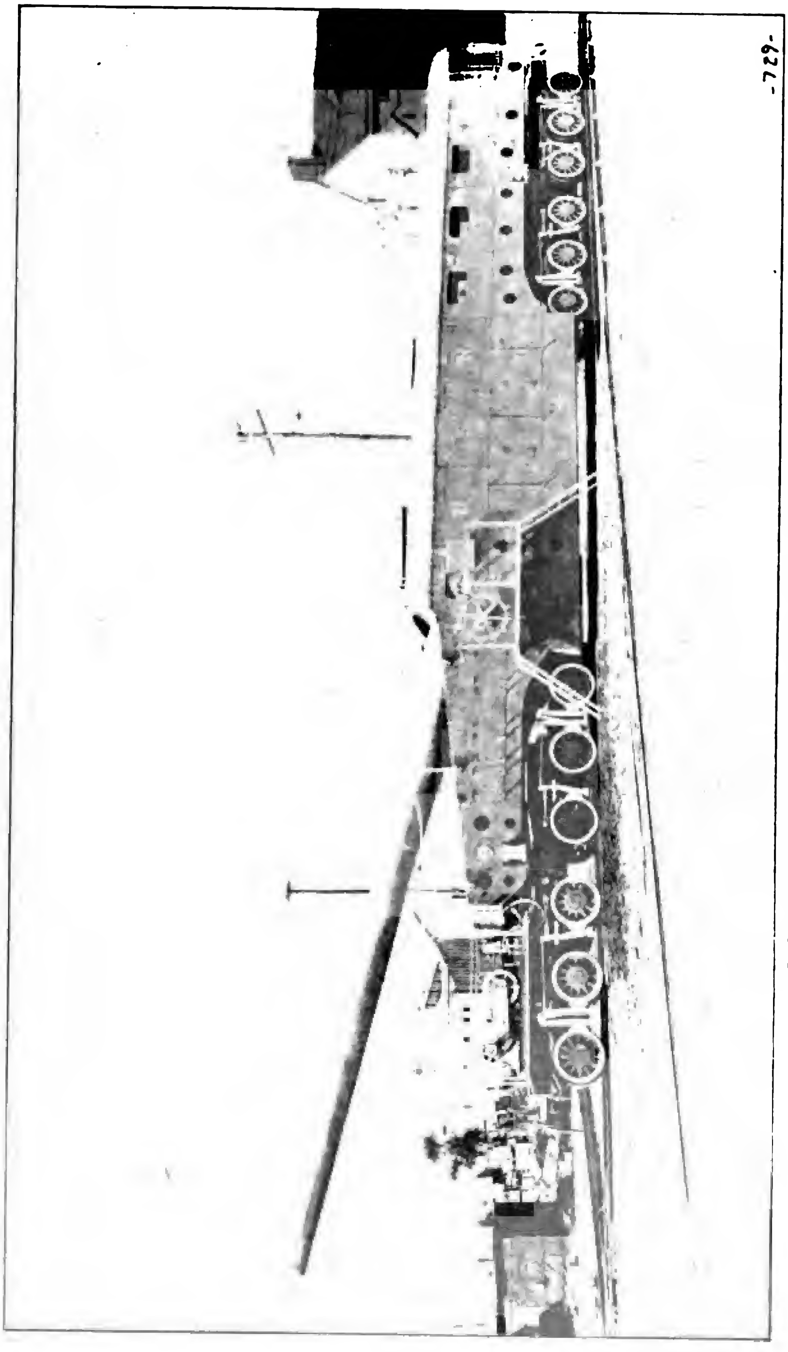


PLATE 254



14-INCH, 50-CALIBER AMERICAN NAVY GUN MOUNT, MARK I.

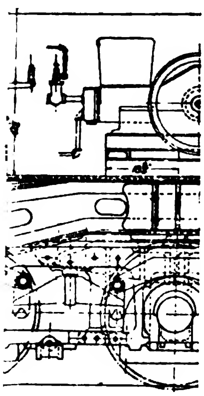
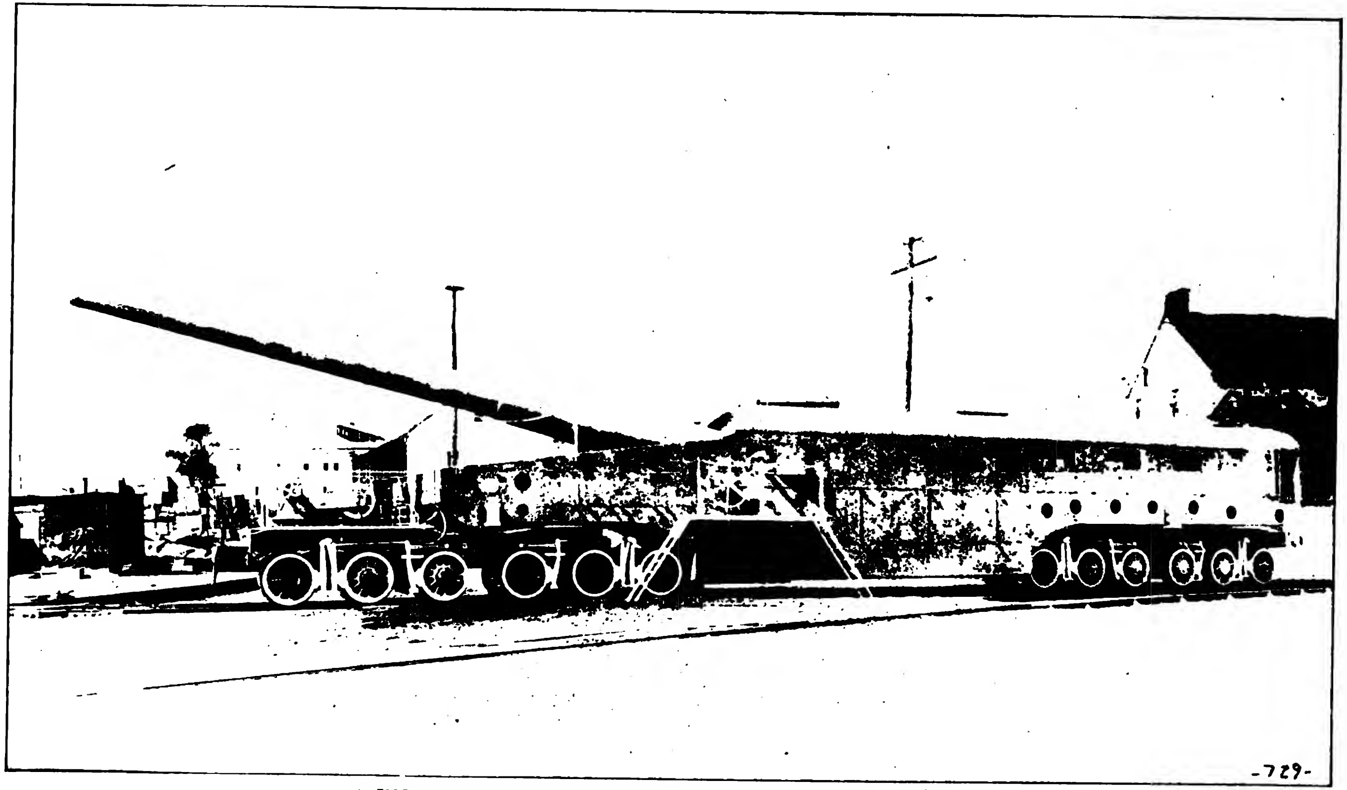


PLATE 254



14-INCH, 50-CALIBER AMERICAN NAVY GUN MOUNT, MARK I.

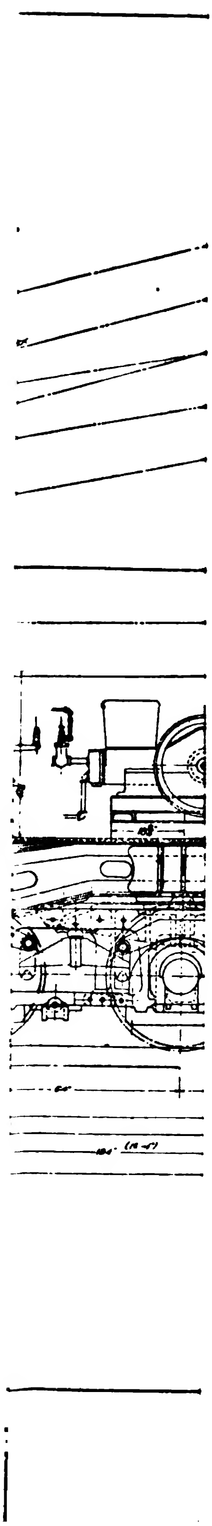


PLATE 255

14-INCH, 50-CALIBER AMERICAN NAVY GUN MOUNT, MARK I.

PLATE 256

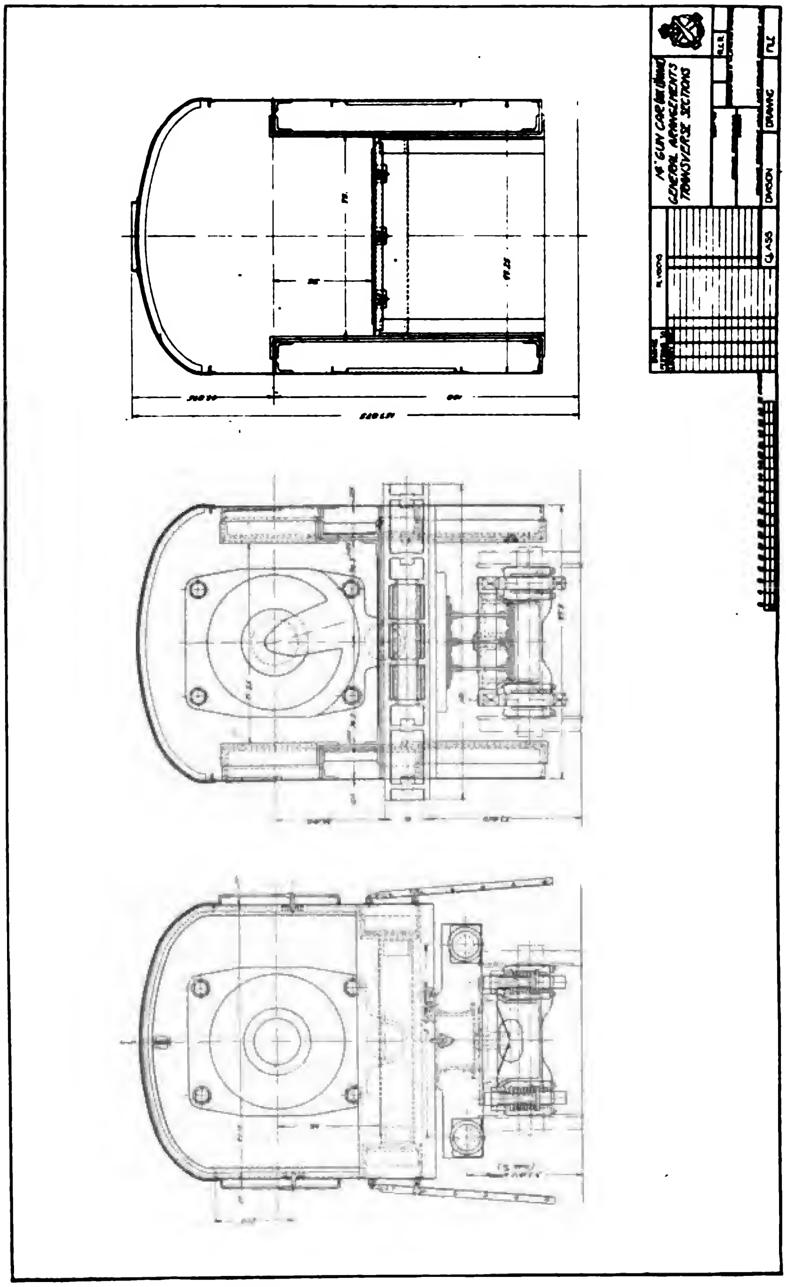

GENERAL ARRANGEMENTS
TRANSVERSE SECTIONS
CLASS
DIVISION
DRAWING
FILE

PLATE 257

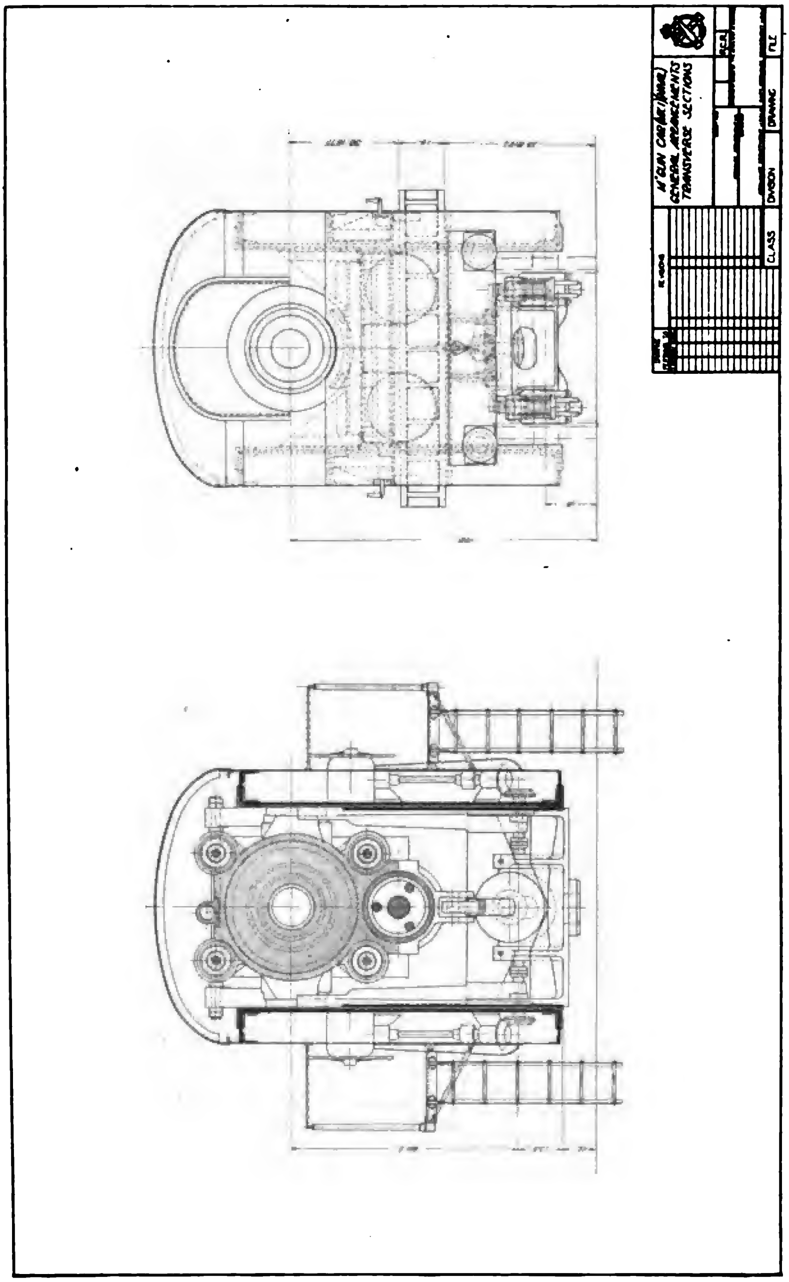

GENERAL ARRANGEMENTS
TRANSVERSE SECTIONS
CLASS
DIVISION
DRAWING
FILE

PLATE 258

14-INCH, 50-CALIBER AMERICAN NAVY GUN MOUNT, MARK I, IN COURSE OF ERECTION IN THE CHANTIERS DE LA LOIRE ST. NAZAIRE, FRANCE.

PLATE 259

14-INCH, 50-CALIBER AMERICAN NAVY GUN MOUNT, MARK I, PARTIALLY ERECTED IN THE CHANTIERS DE LA LOIRE, ST. NAZAIRE FRANCE.

PLATE 260

14-INCH, 50-CALIBER AMERICAN NAVY GUN MOUNT, MARK I, IN OPERATION NEAR VERDUN, AGAINST GERMAN RAILWAY YARDS AT MONT MEDY, NOVEMBER, 1918.

PLATE 261

14-INCH, 50-CALIBER AMERICAN NAVY GUN MOUNT, MARK I, IN OPERATION NEAR VERDUN, AGAINST GERMAN RAILWAY YARDS AT LONGUYON, NOVEMBER, 1918.

PLATE 262

14-INCH, 50-CALIBER AMERICAN NAVY GUN MOUNT, MARK I, LOCATED NEAR VERDUN, NOVEMBER, 1918 (BEING CAMOUFLAGED WITH CANVAS).

PLATE 263

14-INCH, 50-CALIBER AMERICAN NAVY GUN MOUNT, MARK I (JUST ARRIVED CHANTIERS DE LA GIRONDE, BORDEAUX, FRANCE, JANUARY, 1918, FOR DISASSEMBLY).

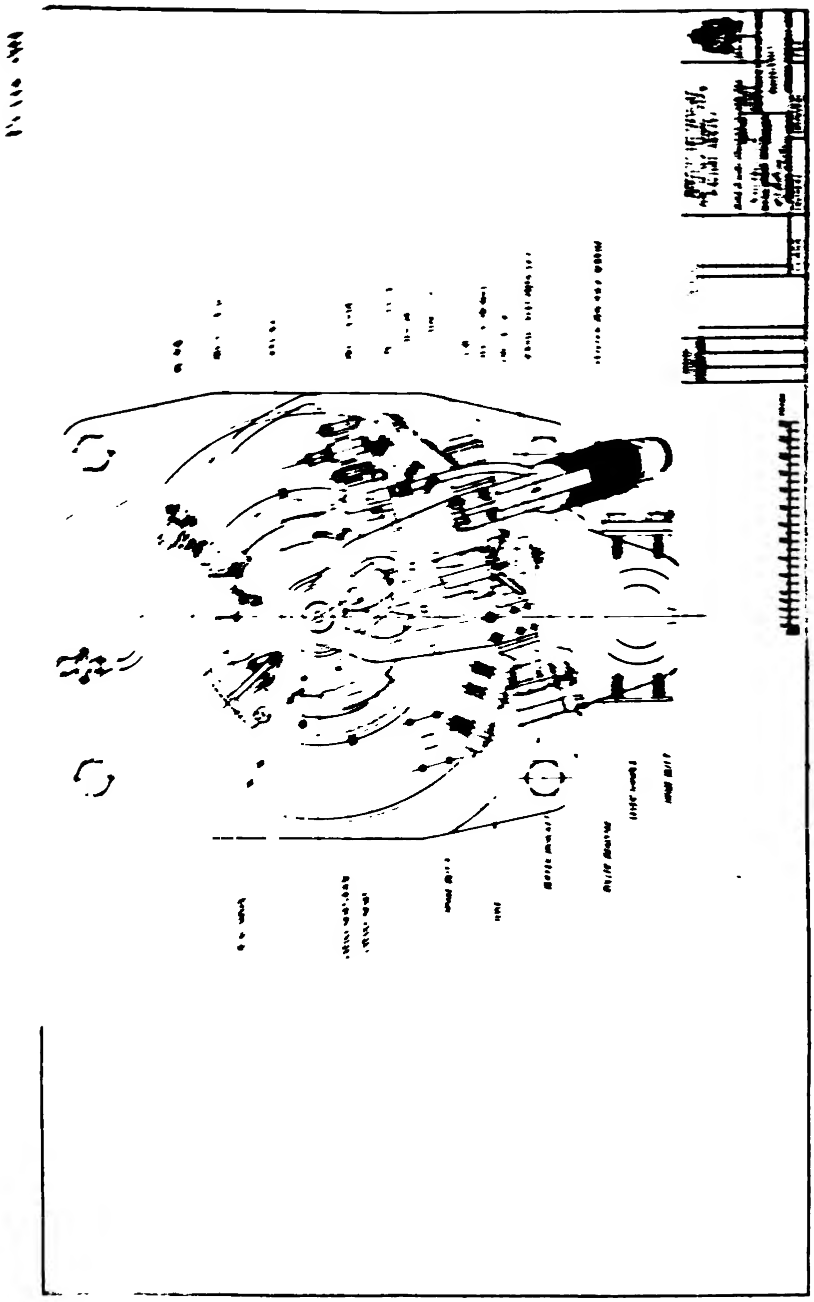


PLATE 205

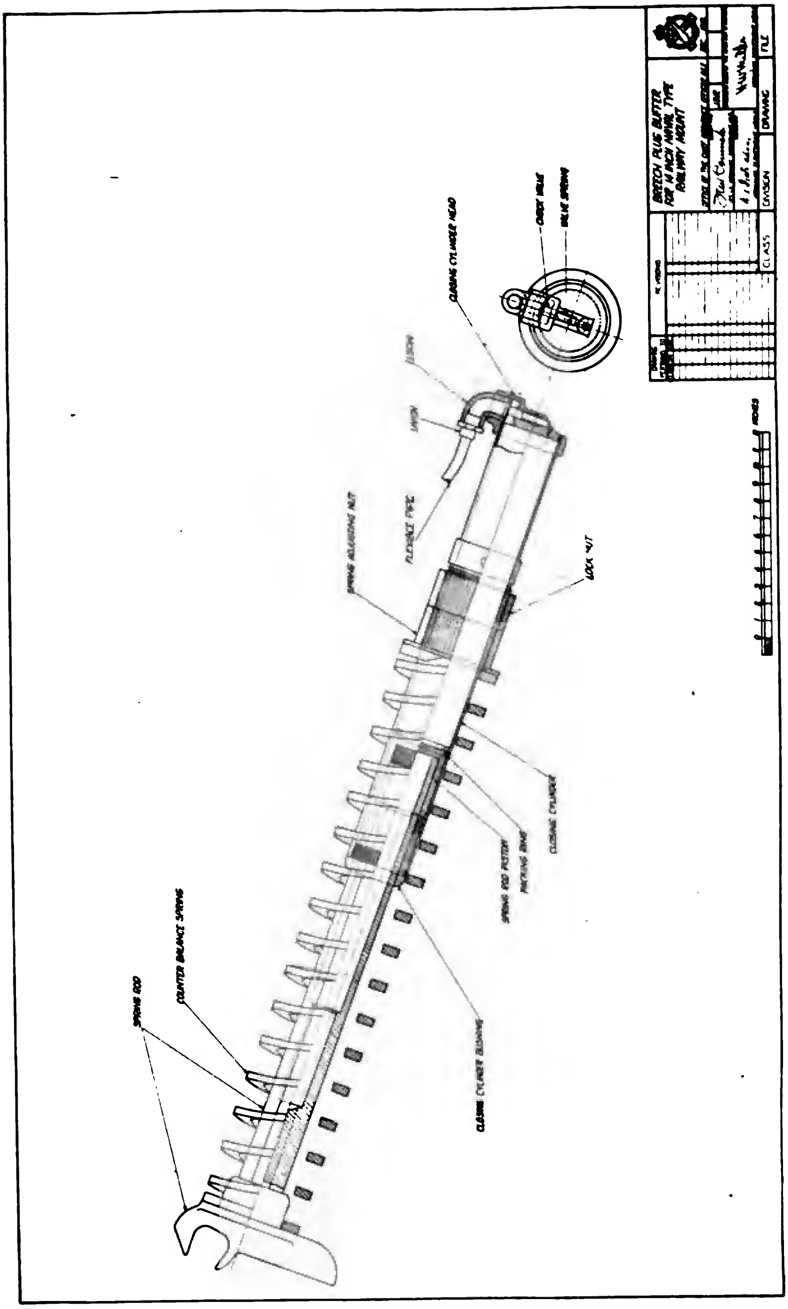

BREECH PLUG BUFFER
FOR 14 INCH NAVAL TYPE
RAILWAY MOUNT
SPRING ROD
COUNTER BALANCE SPRING
CLOSING CYLINDER BUSHING
SPRING ROD PISTON
PACKING RING
CLOSING CYLINDER
LOCK NUT
SPRING ADJUSTING NUT
FLEXIBLE PIPE
UNION
CLOSING CYLINDER HEAD
CHECK VALVE
VALVE SPRING
CLASS
DIVISION
DRAWING
FILE

PLATE 266

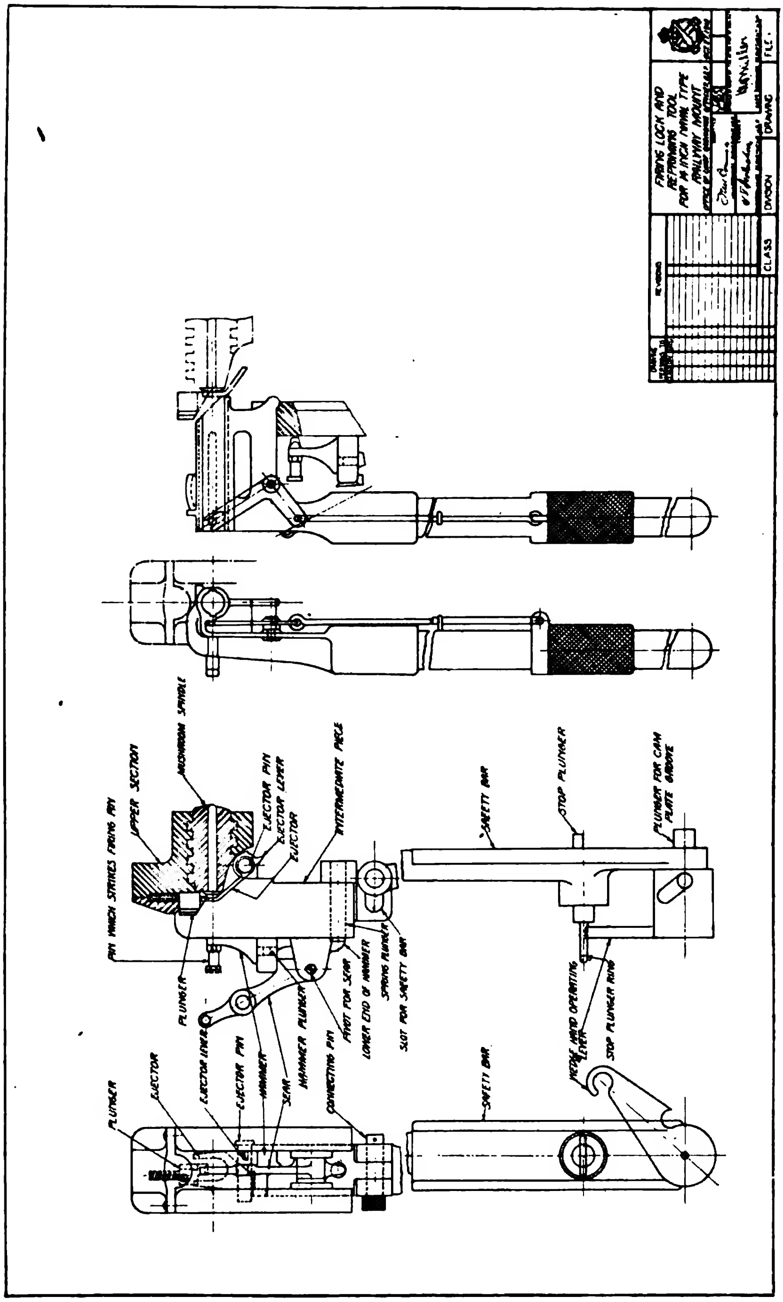

PIN WHICH STRIKES FIRING PIN
UPPER SECTION
MUSHROOM SPINDLE
EJECTOR PIN
EJECTOR LEVER
EJECTOR
INTERMEDIATE PIECE
PLUNGER
HAMMER PLUNGER
PIVOT FOR SEAR
LOWER END OF HAMMER
SPRING PLUNGER
SLOT FOR SAFETY BAR
SAFETY BAR
STOP PLUNGER
PLUNGER FOR CAM PLATE GROOVE
HAND OPERATING LEVER
STOP PLUNGER RING
EJECTOR LEVER
EJECTOR PIN
HAMMER
SEAR
CONNECTING PIN
CLASS
DIVISION
DRAWING
FILE

PLATE 267

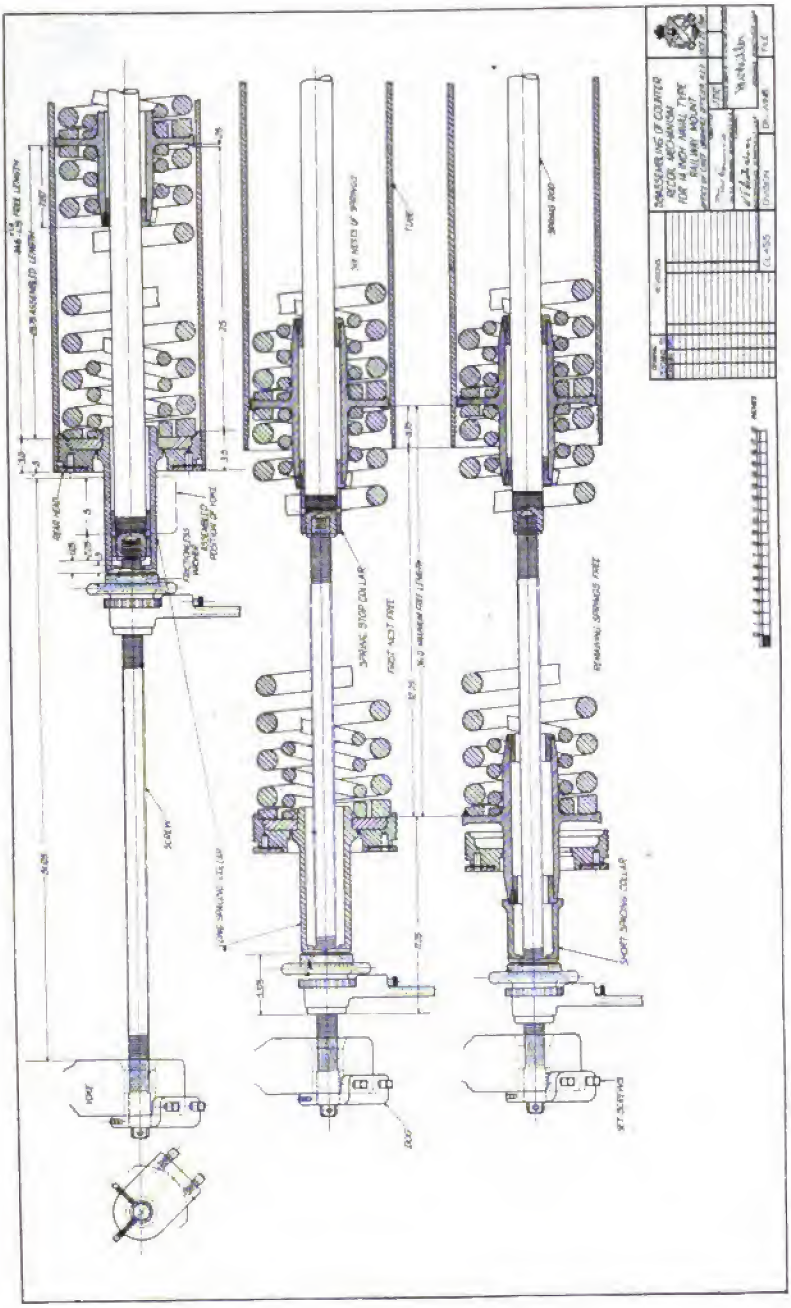

DISASSEMBLING OF COUNTER RECOIL MECHANISM FOR 14 INCH NAVAL TYPE RAILWAY MOUNT
SIX NESTS OF SPRINGS
TUBE
SPRING ROD
REAR HEAD
FRICTIONLESS WASHER
ASSEMBLED POSITION OF YOKE
SPRING STOP COLLAR
FIRST NEST FREE
REMAINING SPRINGS FREE
SCREW
LONG SPACING COLLAR
SHORT SPACING COLLAR
YOKE
DOG
SET SCREWS

Plate 268

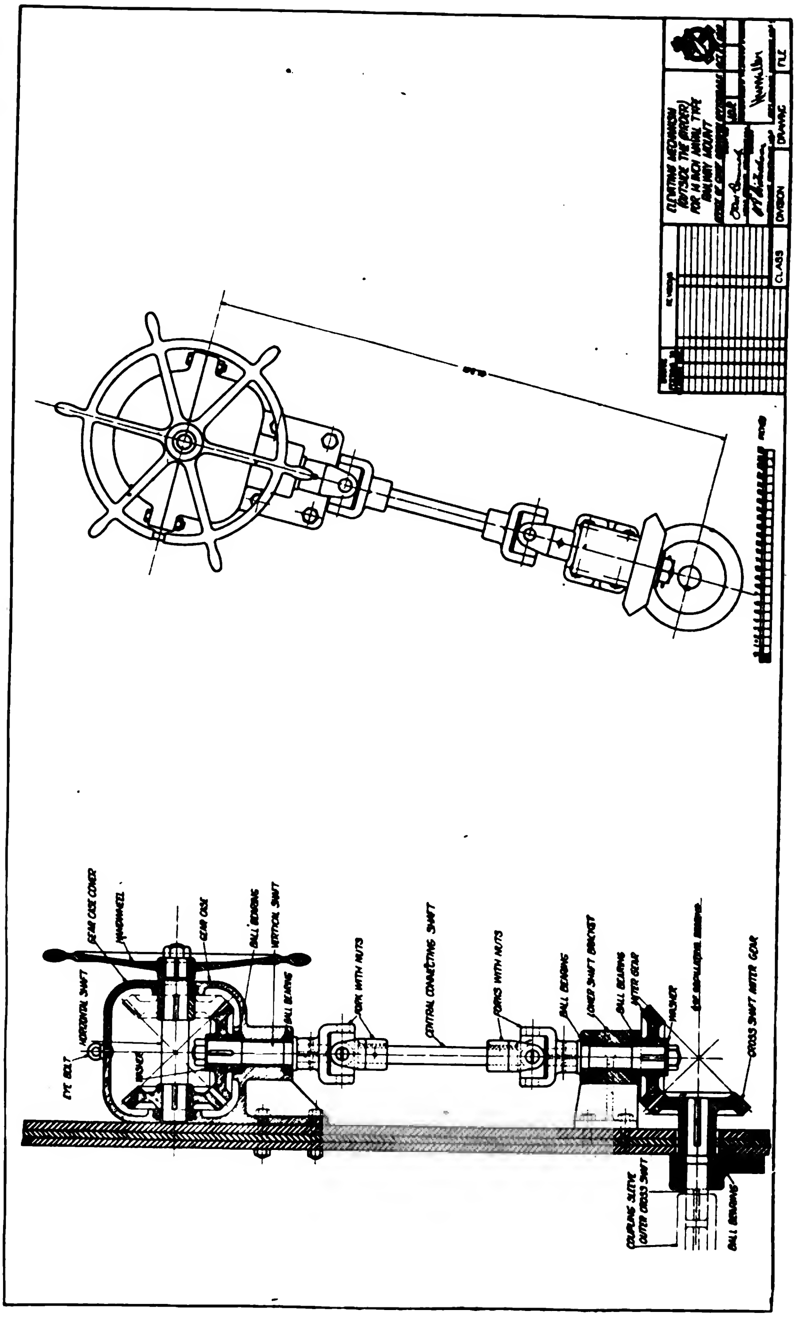

EYE BOLT
HORIZONTAL SHAFT
GEAR CASE COVER
HANDWHEEL
GEAR CASE
BALL BEARING
VERTICAL SHAFT
FORK WITH NUTS
CENTRAL CONNECTING SHAFT
FORKS WITH NUTS
LOWER SHAFT BRACKET
MITER GEAR
WASHER
CROSS SHAFT MITER GEAR
COUPLING SLEEVE
OUTER CROSS SHAFT
CLASS
DIVISION
DRAWING
FILE

Plate 269

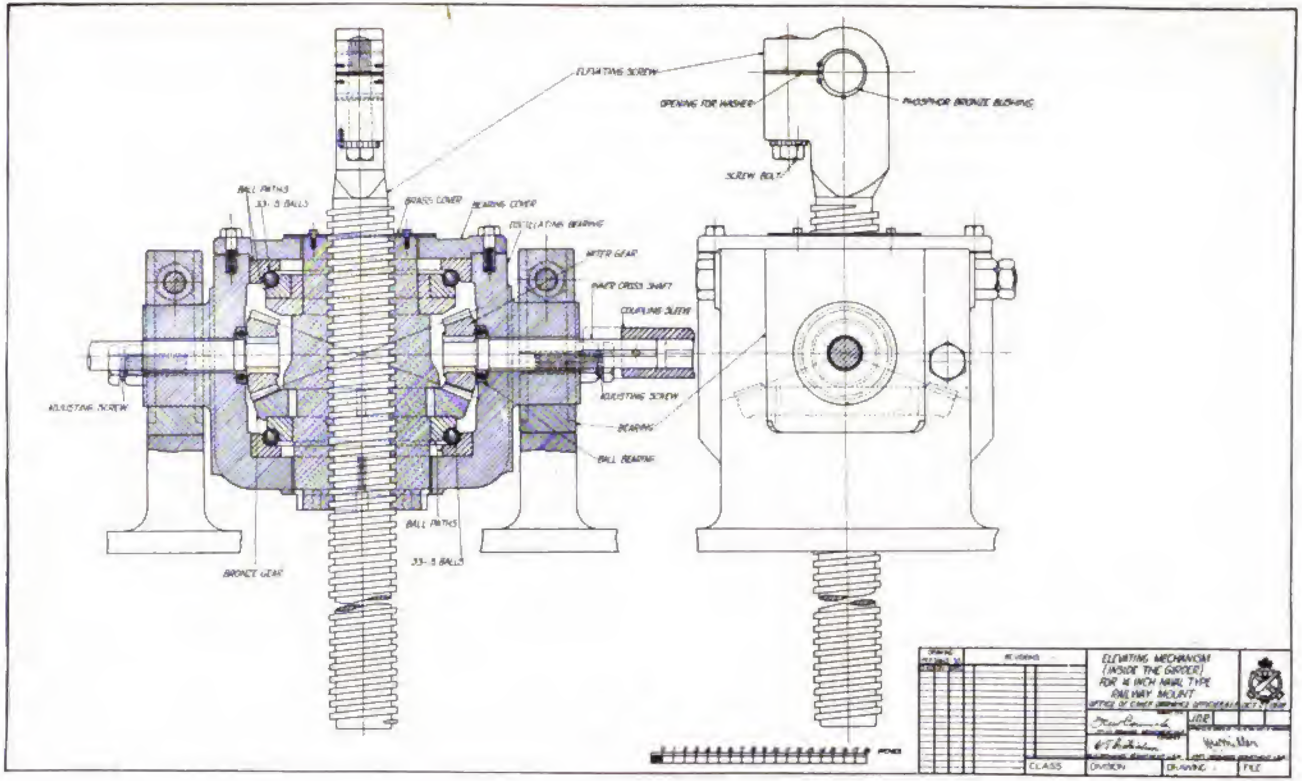

ELEVATING SCREW
OPENING FOR WASHER
PHOSPHOR BRONZE BUSHING
SCREW BOLT
BALL PATHS
33- 3 BALLS
BRASS COVER
BEARING COVER
OSCILLATING BEARING
MITER GEAR
INNER CROSS SHAFT
COUPLING SLEEVE
ADJUSTING SCREW
BEARING
BALL BEARING
BRONZE GEAR
ELEVATING MECHANISM
(INSIDE THE GIRDER)
FOR 14 INCH NAVAL TYPE
RAILWAY MOUNT
CLASS
DIVISION
DRAWING
FILE

Plate 270

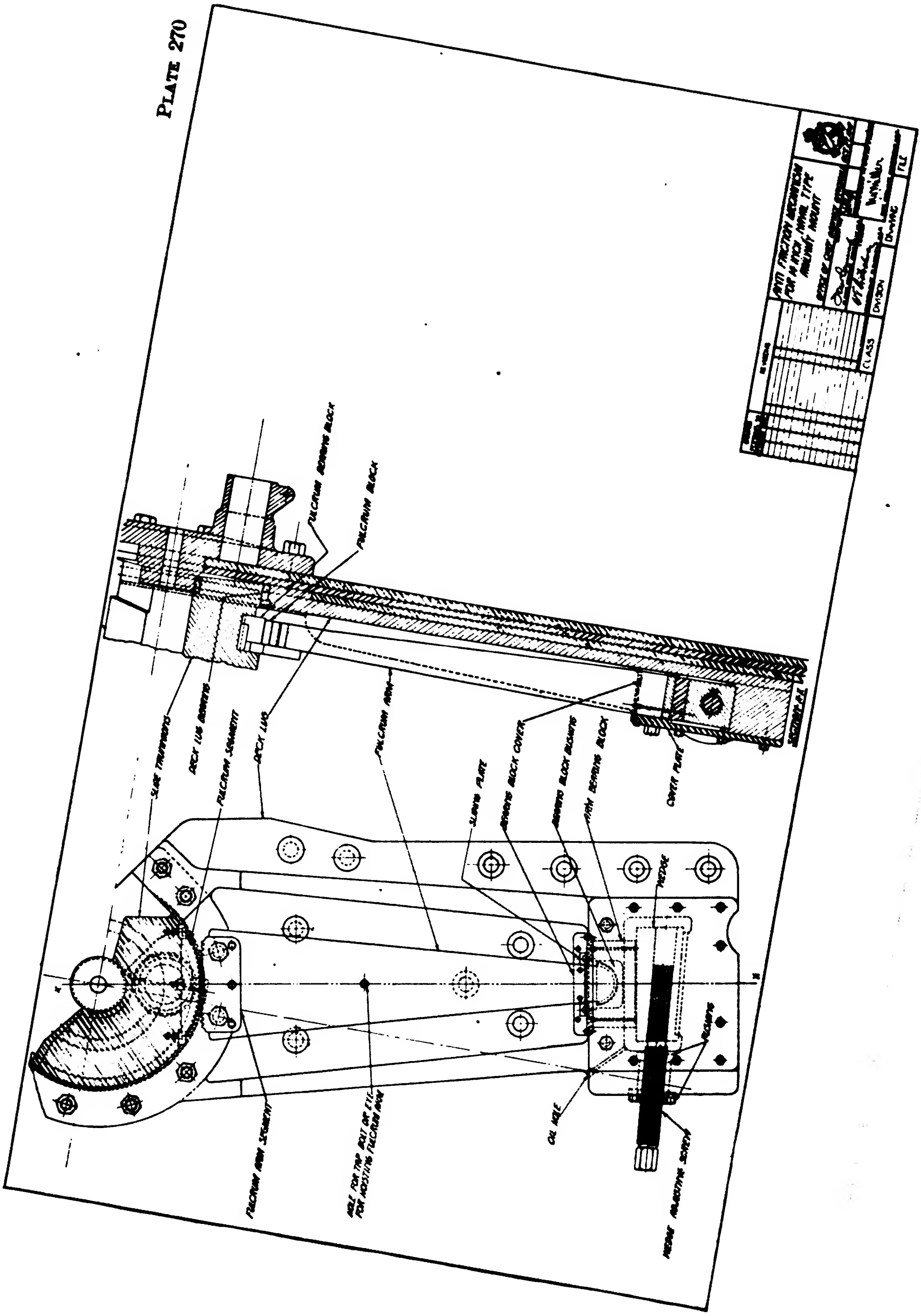


PLATE 271

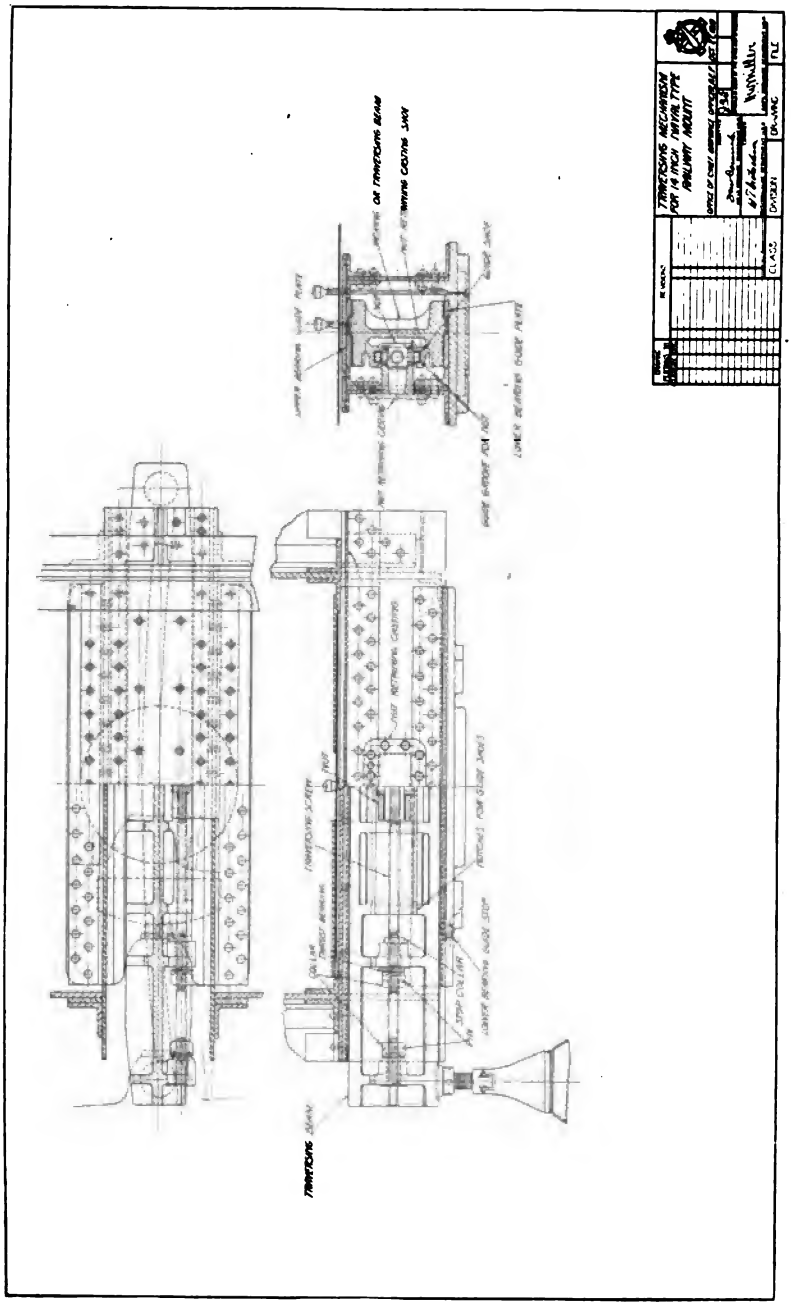


PLATE 272

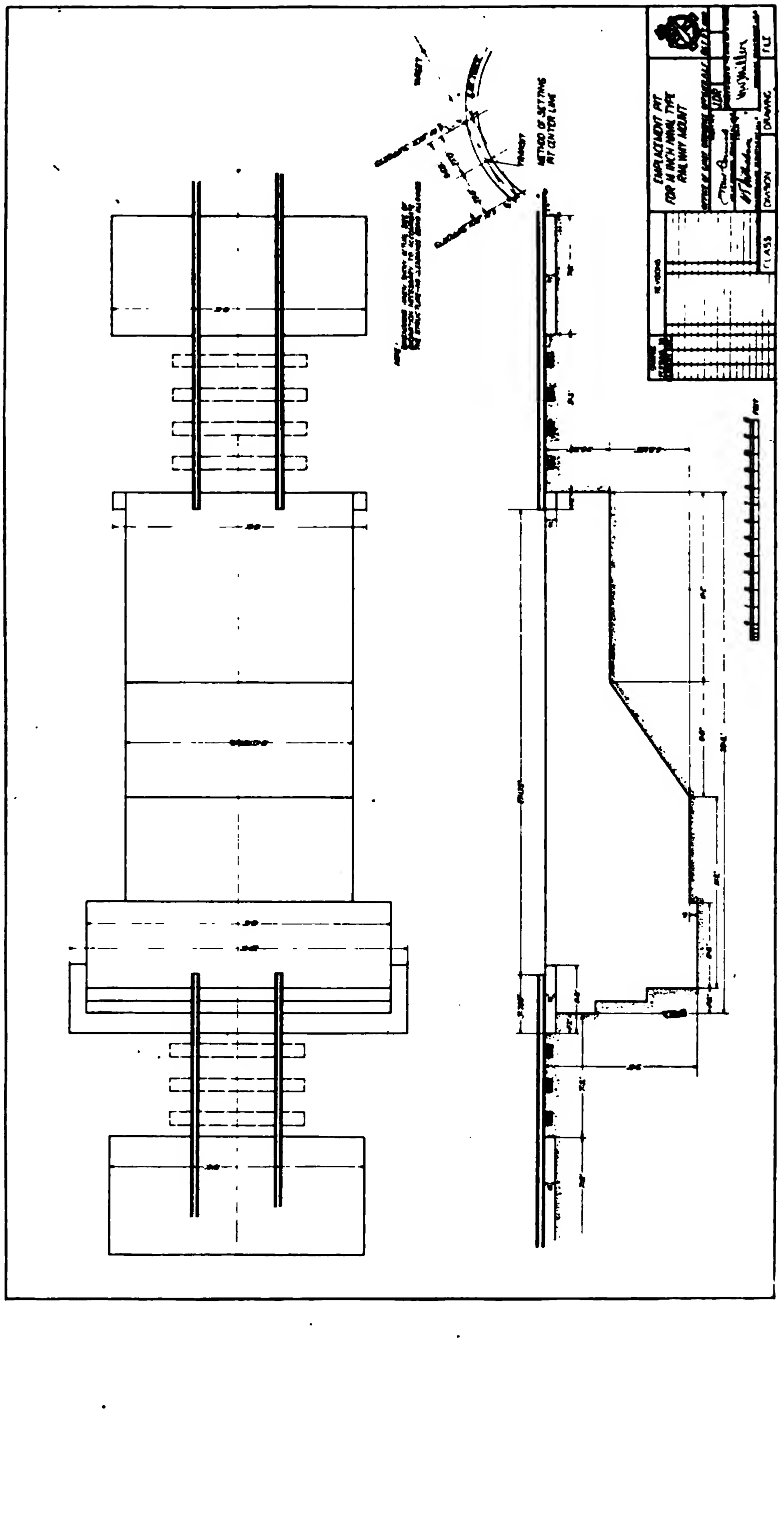

EMPLACEMENT PIT FOR 14 INCH NAVAL TYPE RAILWAY MOUNT
METHOD OF SETTING PIT CENTER LINE

PLATE 273

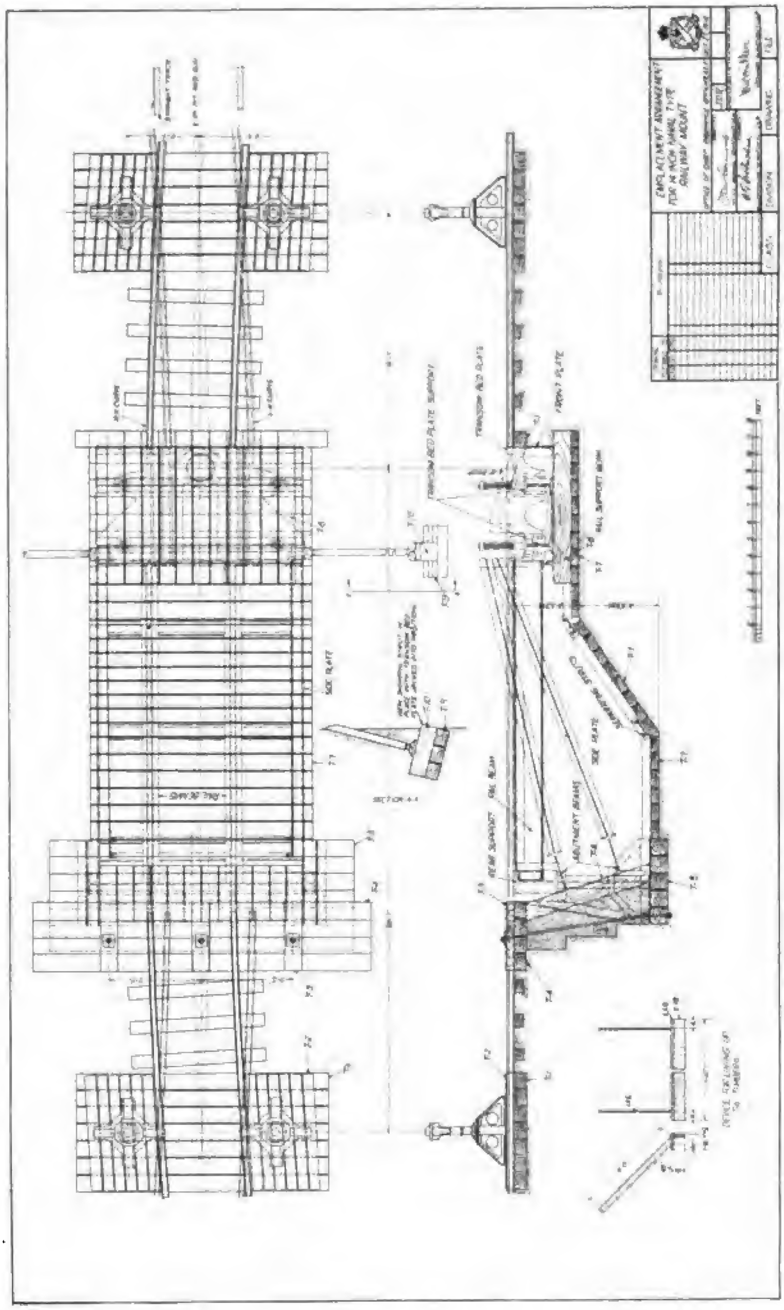

EMPLACEMENT ARRANGEMENT FOR 14 INCH NAVAL TYPE RAILWAY MOUNT
FRONT PLATE
SIDE PLATE
RAIL BEAMS
SECTION A-A

PLATE 274

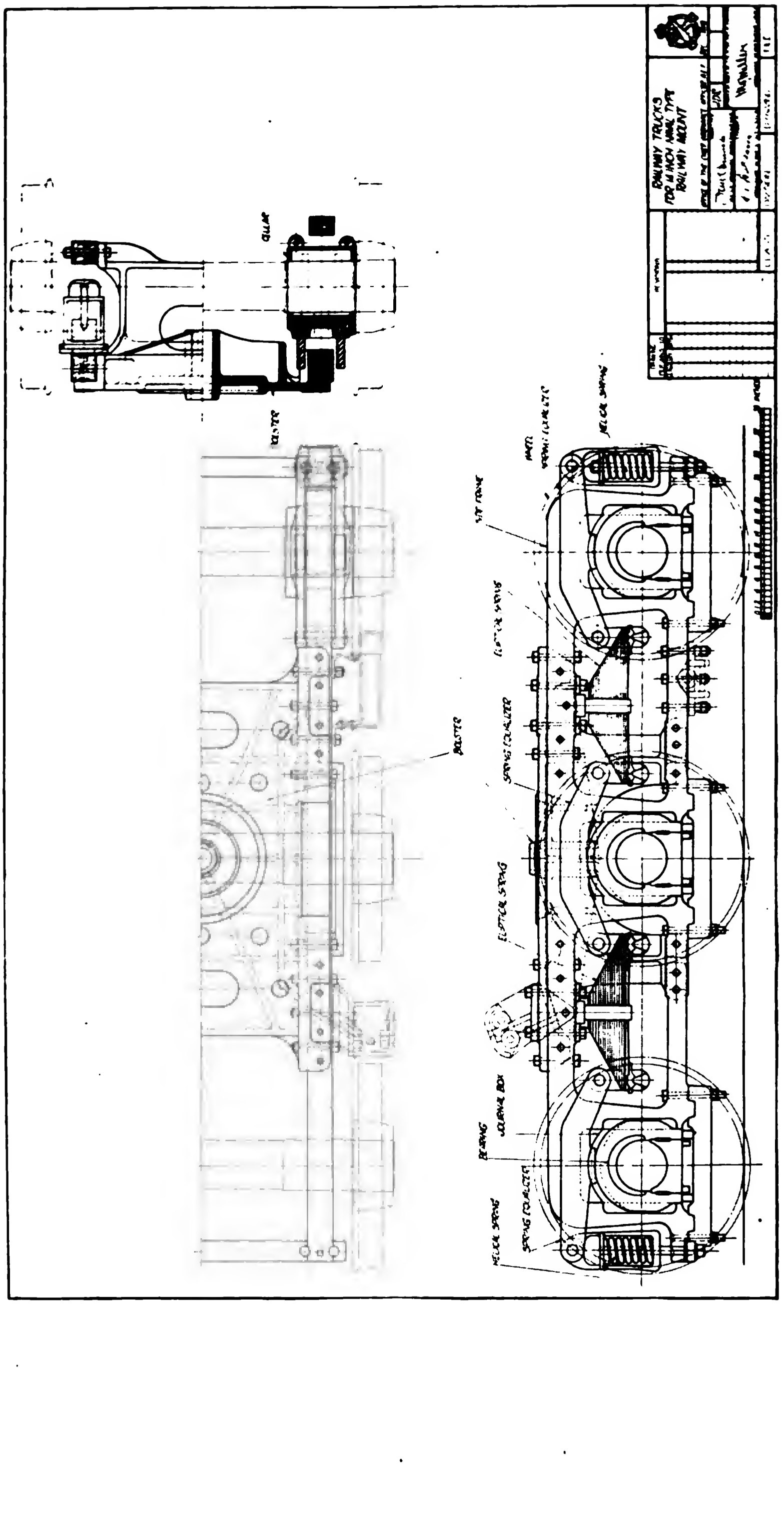


PLATE 275

AMMUNITION CAR FOR THE 14-INCH, 50-CALIBER AMERICAN NAVY GUN MOUNTS, MARKS I AND II.

PLATE 270

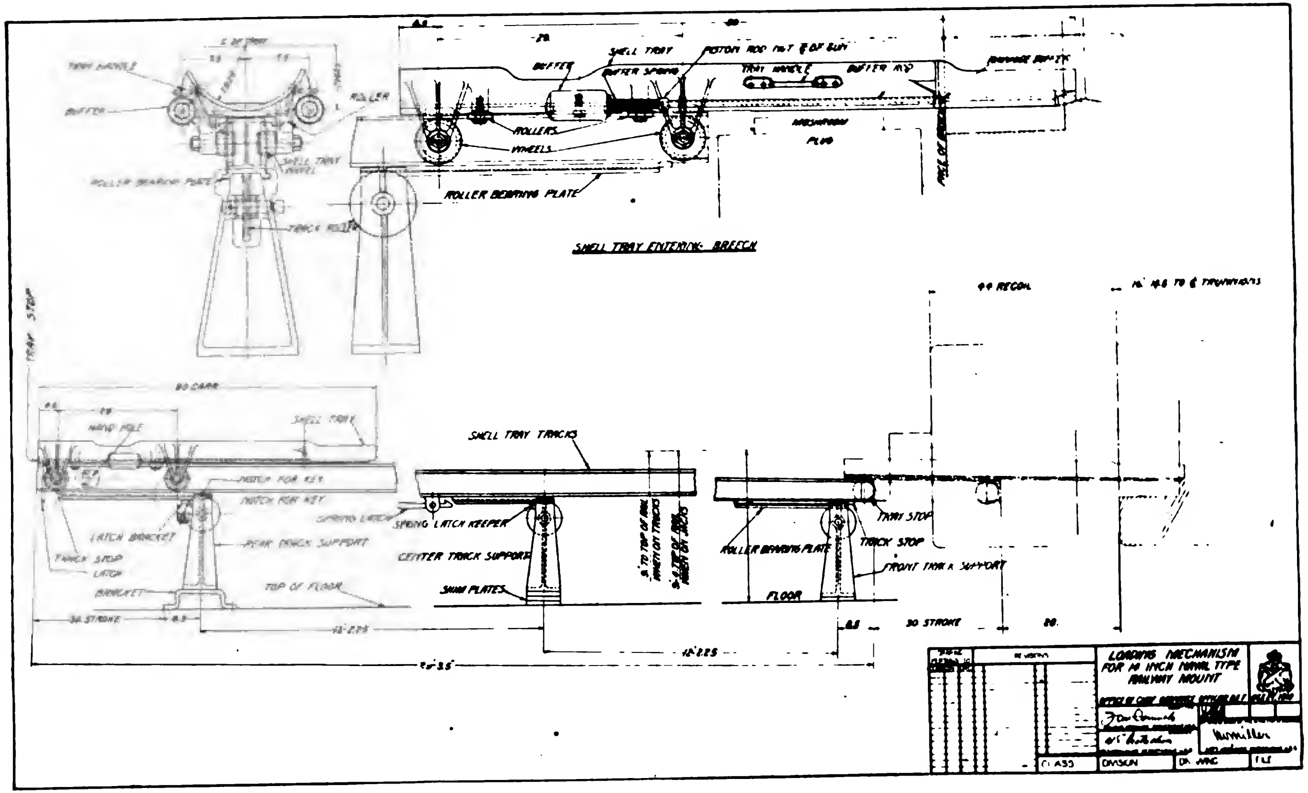

SHELL TRAY ENTERING BREECH
SHELL TRAY
BUFFER
BUFFER SPRING
PISTON ROD NUT
TRAY HANDLE
ROLLERS
WHEELS
ROLLER BEARING PLATE
MUSHROOM PLUG
SHELL TRAY TRACKS
SPRING LATCH KEEPER
CENTER TRACK SUPPORT
SHIM PLATES
ROLLER BEARING PLATE
FLOOR
TRAY STOP
TRACK STOP
FRONT TRACK SUPPORT
30 STROKE
REAR TRACK SUPPORT
TOP OF FLOOR
LATCH BRACKET
HAND HOLE
SHELL TRAY
LOADING MECHANISM
FOR 14 INCH NAVAL TYPE
RAILWAY MOUNT
CLASS
DIVISION

PLATE 277

INTERIOR OF PERSONNEL CAR FOR AMERICAN NAVY RAILWAY ARTILLERY.

11.—AMERICAN 14-INCH GUN ON NAVY RAILWAY MOUNT, MARK II. (24)

239. This mount is of the combined cradle and rolling recoil type. The gun is mounted in a cradle having a combined hydrospring and pneumatic recoil mechanism. This cradle is mounted in a heavy cast-steel slide which is carried in guides attached to the side girders. This slide is capable of moving upward at an angle of 45 degrees with the vertical, through a distance of 86 inches above the traveling position. The structural steel girder is supported at each end by a span bolster on two five-axle trucks. Neither the car body nor the gun is provided with any traverse, and it is necessary to operate the mount on a curved track. When the gun is fired, the entire mount rolls back on the track a distance of from 30 to 40 feet. General views are shown on plates 279, 280, 281, and 282.

240. GUN.—The gun for which this mount was primarily designed is identical with that used on the railway mount, Mark I—that is, a 14-inch naval rifle, Mark IV, Modification I, of 50-caliber length. It is possible, however, to mount a 9-inch gun with its cradle in the same slide.

241. RECOIL MECHANISM.—The recoil mechanism proper is in every respect identical with that of the 14-inch gun used on the railway mount Mark I, plate 34. The difference in respect to recoil, between the Mark II and Mark I mounts, is that on the Mark II mount the gun can be fired without any track preparation whatever to its maximum elevation of 40 degrees, while on the Mark I mount it is possible to fire the gun to an elevation of only 15 degrees without track preparation. The maximum recoil of the 14-inch gun is 44 inches when the gun is operated at the maximum elevation of 40 degrees. The recoil of the 9-inch guns at 43 degrees is 36 inches. The air for recuperator cylinder is supplied from the air pump installed on the front span bolster, plate 279.

242. ELEVATING MECHANISM.—The elevating mechanism in its essential details is identical with that of the Mark I mount, shown on plates 268 and 269. The only difference is in the connections between the handwheels and cross shafts which drive the miter gears in the gear case. This modified connection is shown on plate 284 in the central figure. It will be observed here that handwheels are mounted directly on shafts which carry pinions on the inner ends meshing with spur gears carried directly on the cross shafts.

243. TRAVERSING MECHANISM.—It has already been mentioned that this carriage is not provided with any internal traversing mechanism. It is necessary to operate it on a curved track to train the gun in azimuth.

244. GUN CARRIAGE.—The cast-steel slide in which the gun and its cradle are carried will be described under this head. One of the

qualifications desired of heavy railway mounts during the present war was a practicable means of rapidly installing an emplacement or otherwise preparing for action. With most heavy gun carriages it was necessary to provide some design of ground platform for operating the gun at high elevations. This provision of a heavy ground platform was necessitated by two considerations. When operating the gun at high elevations, the vertical component of the shock of recoil is ordinarily greater than can safely be transmitted through any except extremely heavy trucks. The second consideration is that if the gun is to be operated at its maximum elevation without the use of a subtrack platform and pit under the center of the gun, it is necessary either to place the trunnions very close to the breech of the gun or elevate the trunnions above the track by some method in order that the breech of the gun may not strike the ties at full recoil.

245. It was understood, of course, that any gun mount operating without a subtrack platform would have to be either of the sliding or rolling recoil type. On the Armstrong 14-inch mount this problem was solved by mounting the gun in a cradle, whose trunnions are close to the breech of the gun, and by connecting the rear end of the cradle with the piston of a large air cylinder by means of two connecting rods, in order that the extreme muzzle preponderance of the gun might be counterbalanced. On the new French 340-millimeter gun carriage the French designers solve this problem by providing two sets of trunnion bearings. The low trunnion bearings are to be used for transportation of the gun which will be transferred to the high trunnion bearings for firing. In the design made for the Army 16-inch gun early in 1918, it was proposed to raise the center line of the trunnions of the gun by means of a slide somewhat similar to this, but sliding in vertical instead of inclined guides.

246. The slide of the 14-inch Mark II mount is shown at its lowest position on plate 280 and at its highest position on plate 281. On plate 283 it is shown in detail with the mechanism used in elevating it. Two 9-inch pistons connected to the slide enter hydraulic cylinders attached to the body of the car. By means of these hydraulic cylinders it is possible to move the slide in the direction of the guides through a distance of 86.28 inches, thereby elevating the center line of the trunnions 61 inches. When at either its upper or lower position the slide is pinned to the carriage by means of two 10-inch pins which are entered or withdrawn by a screw operated by ratchet levers on the outside of the mount, plate 281. These pins, together with the slides and the hydraulic jack, carry the weight of the gun and cradle in transit and transmit the force of recoil into the carriage in firing. The same type of antifriction mechanism that is used on the Mark I mount is incorporated in this design. This is shown on plate 283.

247. **Car Body.**—The car body consists of two heavy single web structural steel girders connected by structural steel transoms. One noticeable difference between this car body and that of the Mark I mount is the absence of armor. All equipment on the top of the carriage, hand rail, hand rail standards, and ammunition trolley, plate 280, is removable for traveling.

248. **Anchorage.**—This is a rolling recoil type of mount and the only means of anchoring it is the friction of the brakes operated by hand. On firing, the entire mount rolls back on the track, a distance of from 30 to 40 feet. On the front span bolster, plate 280, is mounted a motor-driven winch carrying a cable which is attached to the track some distance ahead, and by means of which the mount is returned to its firing position.

249. **Trucks.**—The trucks are ten-wheel locomotive type with 6 by 12-inch journals and 36-inch wheels. As noted before, there are four trucks connected in pairs by structural steel span bolsters. The brakes provided on all trucks can be operated by hand as well as by air. Auxiliary air tanks are charged from the pump mounted just behind the winch on the front span bolster.

250. **Ammunition Supply System.**—On the rear span bolster is mounted a track carrying a steel tray. Both track and tray are practically identical in design with the track and tray provided on Mark I mount and shown on plate 276. When the shell tray is at the forward end of the track, plate 279, the shell is picked up by tongs suspended from the I-beam trolley, shown on plate 280. By means of this trolley the projectile is carried forward and placed on the tray suspended between the stand on the superplatform and the breech of the gun. The gun is loaded at an angle of minus 5 degrees. The loading tray is shown in position on plate 279; it is kept in the alternate position shown when the gun is being fired. A structural steel jib crane is likewise provided on the side of the mount, plate 279, to pick up ammunition from the ground or from another car in the event that it is not practicable to take the ammunition out of the car directly at the rear of the mount.

251. **Maintenance.**—These mounts have not seen any field service and it can not be estimated with certainty just what the extent of the maintenance will be. They are very sturdy in construction and it does not seem probable that they will require excessive service in maintenance. The loads on the axle are such as to avoid the overheating that gave so much trouble on the Mark I mount. The construction of the slide is simple and sturdy and it is not probable that it will give any trouble.

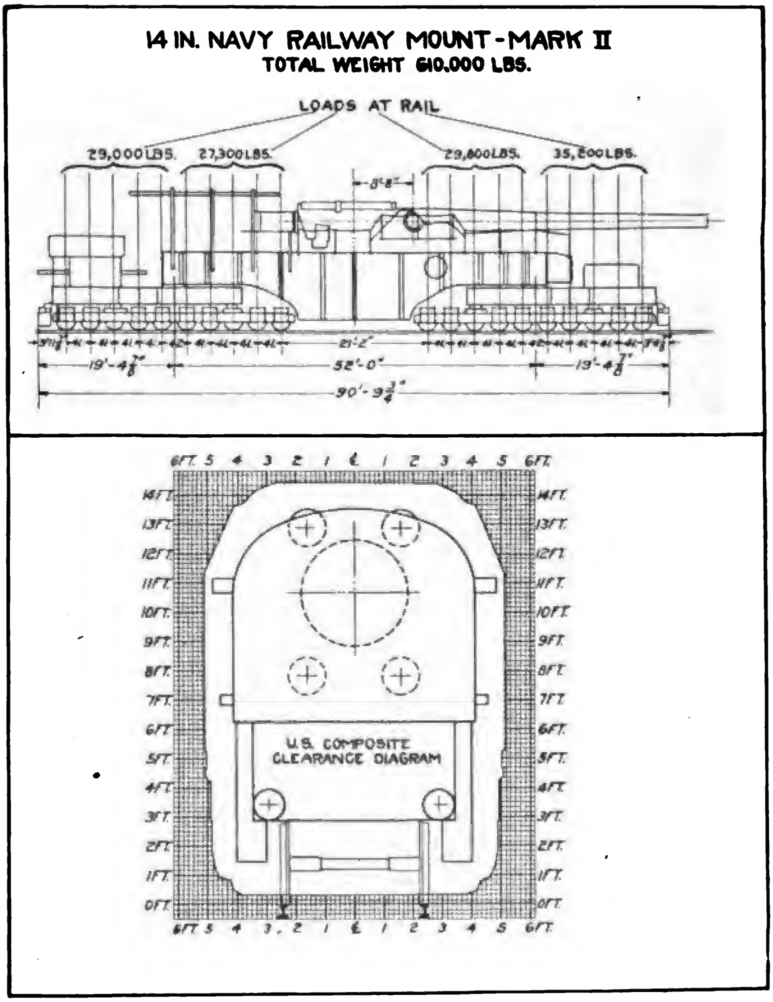
252. **Difficulties Involved in Service.**—The only difficulty that will be involved in the service, if it may really be termed a dif-

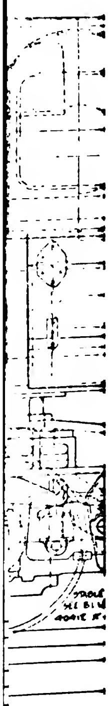
ficulty, will be the construction of the heavy firing positions or epis that are required for training the gun in azimuth. These firing positions are always very well prepared and require an unusual amount of ballast, extra heavy ties and rails, and considerable maintenance while the guns are being operated. The labor required in constructing these epis can not be considered a cause for complaint, because it is ordinarily difficult to keep the personnel of such a battery comfortably busy. The time required for the construction of such epis, however, frequently is a cause for complaint. The time required to lay a new firing track and prepare it for action may vary from two to three days.

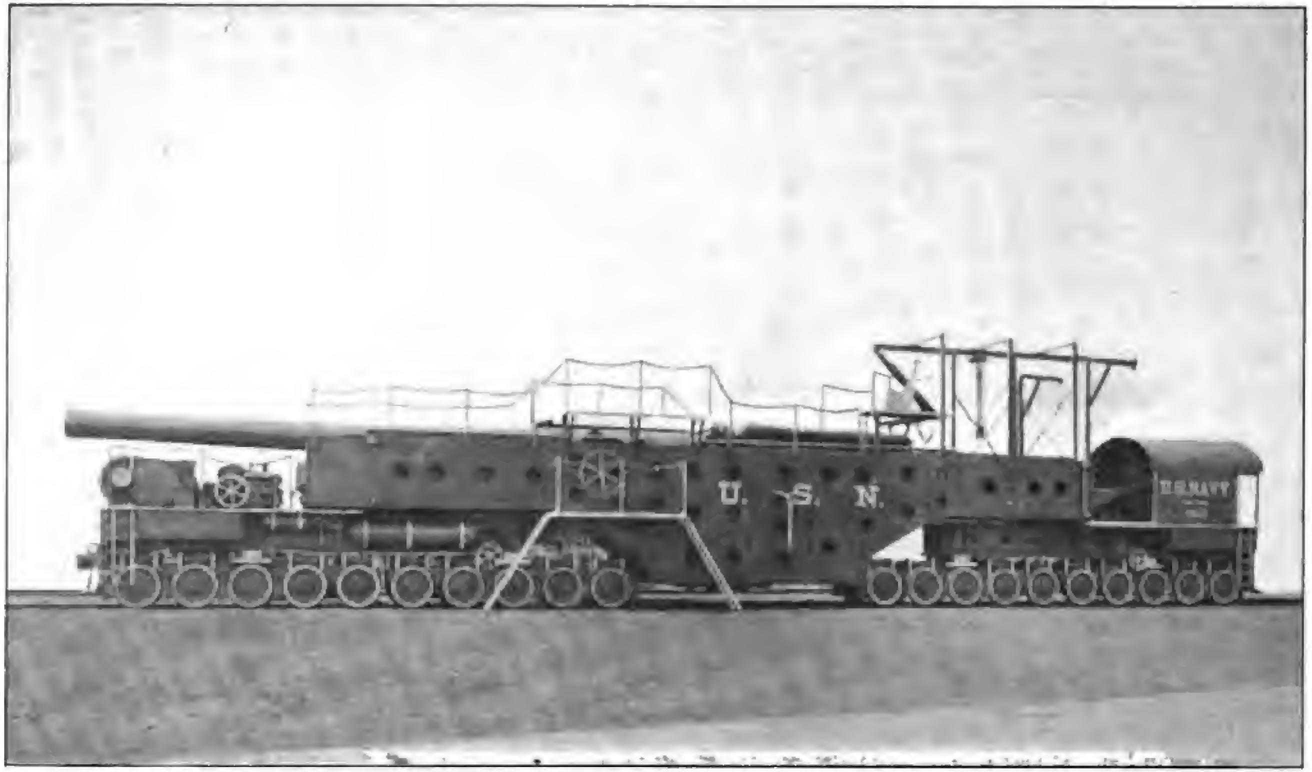
253. Merits.—The merit of the carriage is that it can be fired at the maximum elevation without the installation of firing platforms, which are difficult to install or transport. As just mentioned, occasionally the time required for the installation of a firing track may be a cause for complaint. This is not ordinarily true, however, since the targets on which such guns operate in land warfare, are fixed, and some leisure is available in preparing for action. They are practically self-contained, in that they require no auxiliary equipment for their service. The mount as it is seen on plate 280, practically in traveling order, can be made ready for action in less than an hour, as shown on plate 282.

254. Demerits.—This mount was designed during the active period of the war and was so designed as to be capable of construction in a minimum of time with the manufacturing facilities available. No internal traversing mechanism for fine adjustment of the gun in azimuth has been provided. Such a mechanism is desirable and if more time had been available it is probable that it would have been provided. When considering large gun railway mounts from the standpoint of their use for coast defense, as well as for land warfare it is not certain that this is a desirable type. It is probable that a rolling recoil type of carriage can be operated successfully against a moving target, but it has not been satisfactorily proved. For such a valuable gun it seems now that its carriage should be so designed as to be fitted not only for field service, as this carriage is fitted, but likewise so designed as to be capable of installation on some type of rotable platform in order that it may be easily and accurately traversed and efficiently operated against moving targets.

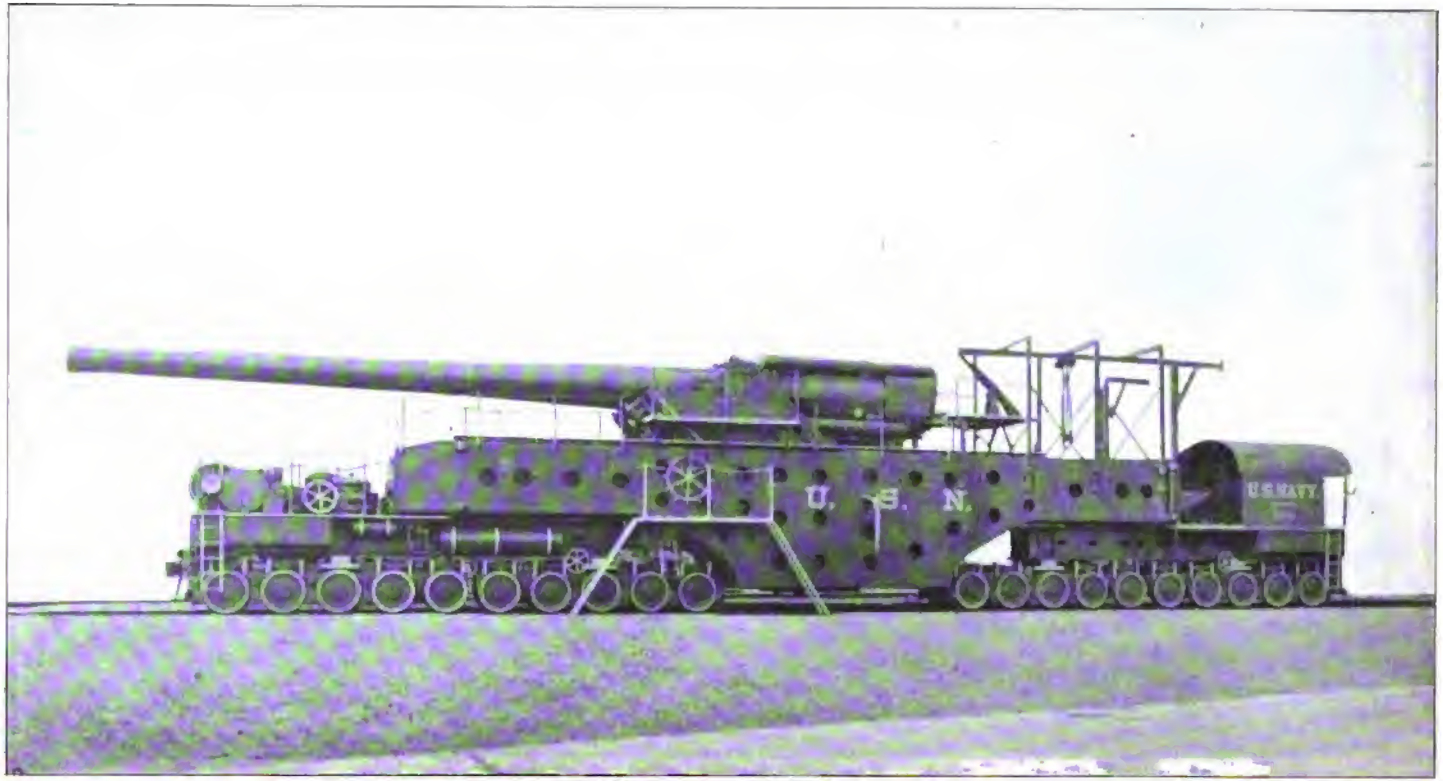
PLATE 278


14 IN. NAVY RAILWAY MOUNT-MARK II
TOTAL WEIGHT 610,000 LBS.
LOADS AT RAIL
29,000 LBS.
27,300 LBS.
29,800 LBS.
35,200 LBS.
8'-8"
21'-2"
19'-4 7/8"
52'-0"
19'-4 7/8"
90'-9 3/4"
U.S. COMPOSITE
CLEARANCE DIAGRAM



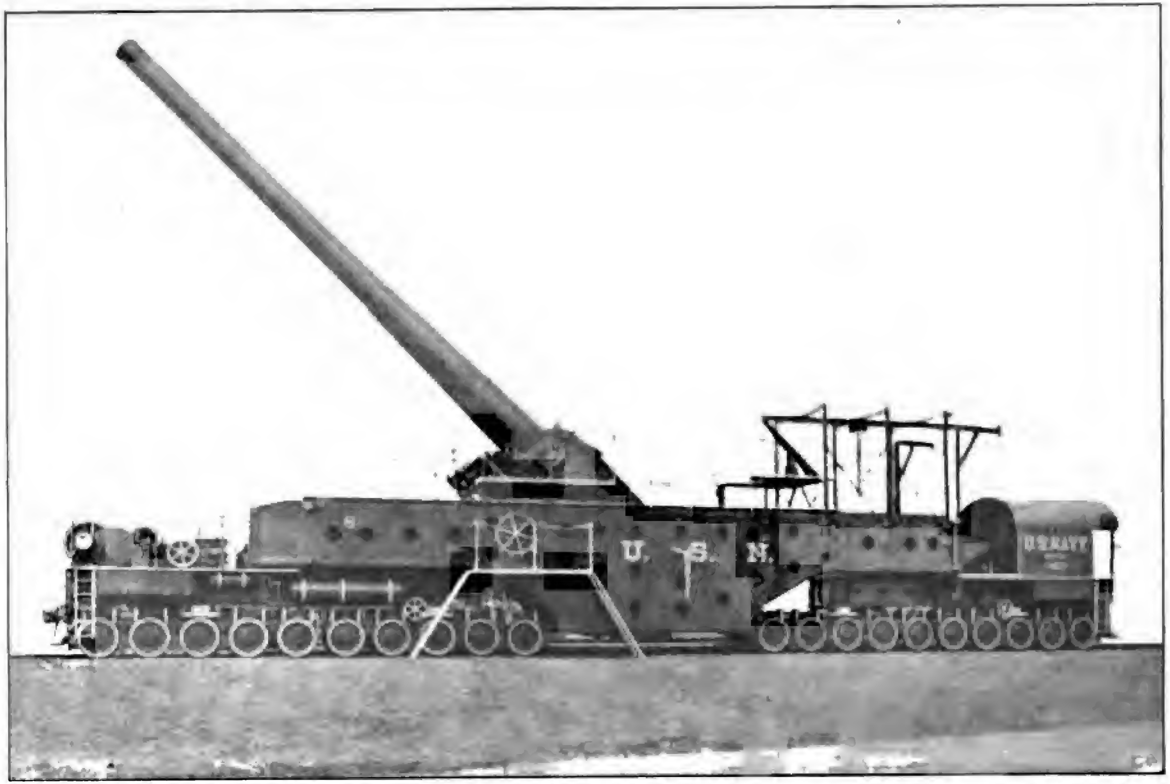


14-INCH, 50-CALIBER AMERICAN NAVY GUN MOUNT, MARK II (ELEVATING CARRIAGE IN TRAVELING POSITION).



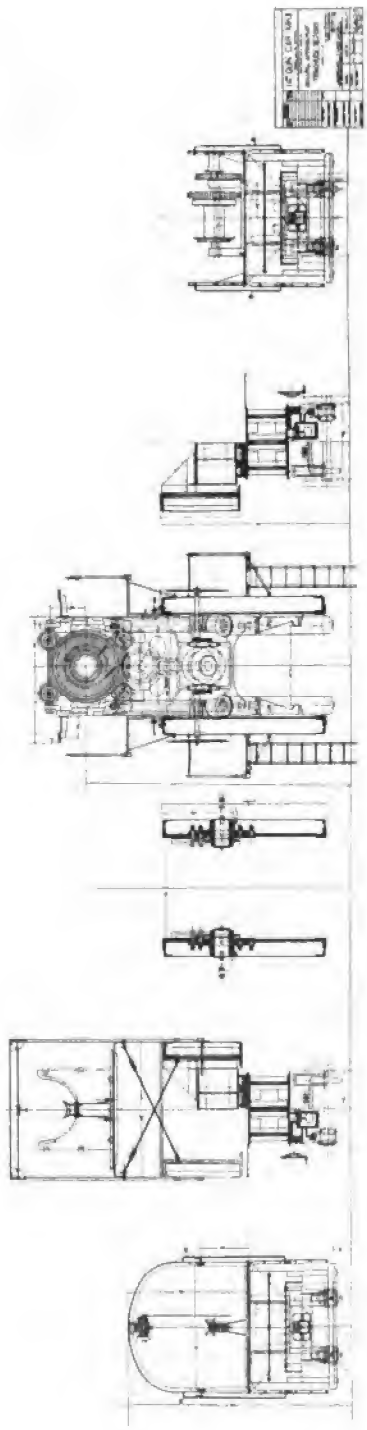
14-INCH, 50-CALIBER AMERICAN NAVY GUN MOUNT, MARK II (ELEVATING CARRIAGE IN FIRING POSITION).

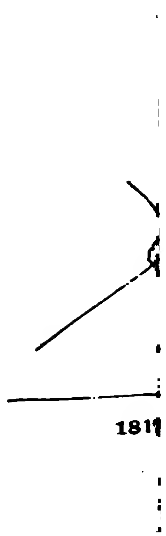
PLATE 282



14-INCH, 50-CALIBER AMERICAN NAVY GUN MOUNT, MARK II (ELEVATING CARRIAGE IN FIRING POSITION, GUN AT 43° ELEVATION).

Plate 284




181

12.—AMERICAN 14-INCH GUN ON SLIDING TYPE RAILWAY MOUNT, MODEL OF 1918. (25)

255. This is a mount of the sliding type. The gun is supported by means of its trunnions directly in bearings attached rigidly to the side girders of the car body. The gun and mount slide back together along the track in recoil exactly as the 10-inch and 12-inch sliding mounts. General views are given on plates 286, 287, 288, and 289. This is one of the two designs made up in France in August, September, and October, 1918, by a combined force of French and American engineers. The French Government had arranged to purchase forty-five 14-inch, 50-caliber guns from the United States; hence the decision on the part of the French and American technical services to combine on a common design of carriage. No carriages of this design have been manufactured and it is probable that none will be. The other of the two designs mentioned above is the next mount described. The essential difference between the two mounts is that on the model 1918 it was planned to use a maximum of structural steel, and on the model 1919 a maximum of steel castings. This resulted, of course, in radical differences in the details of design of many mechanisms, as will be observed in the detailed descriptions.

256. GUN.—The gun employed with this mount is the 14-inch naval rifle, Mark IV, Modification I, of 50-caliber length. It was to be fitted with a trunnion band screwed and shrunk on, plate 290, and it was intended to swing the breechblock to the side instead of down. The breech was likewise to be equipped with a counterweight, plate 291, to allow mounting the trunnions as near the breech end as possible. The breech mechanism has been described in detail under the 14-inch naval mount, Mark I.

257. RECOIL MECHANISM.—No recoil mechanism, as it is ordinarily understood, is used in this mount. When the gun is fired, the shock of recoil is transmitted by the trunnions directly into the car body and the entire mount slides back on the track, being stopped by the friction between the sleepers in the bottom of the car, and the special firing beams laid on the ties.

258. ELEVATING MECHANISM.—The gun can be elevated from 1 degree 30 minutes, the loading angle, to a maximum of 38 degrees, by a combined hand and electric power operated mechanism, the design of which is shown on plates 292 and 293. The elevating rack is bolted to the counterweight on the right-hand side, and as noted before, the gun can be elevated either by hand power through the handwheels mounted on the tops of the two side girders, or by means of the electric motor located some distance forward and between the girders. The power for operating the elevating motor was to be supplied from a gasoline-electric generator that was likewise to be

mounted within the car body. This same generator was to furnish power for elevating the gun and for translating the mount along the track. To protect the generator from being damaged by excessive strains in firing, it was intended to mount it on a sliding base equipped with spring or hydraulic buffers. When operated by hand, one revolution of the handwheel moves the gun through 0.48 degree in elevation. The motor is 7½ horsepower and is connected with the worm shaft by means of a chain. A clutch is provided so that the handwheel does not rotate when the motor is being used. An antifriction device of the design shown on plate 294, is incorporated in the mechanism. This type of antifriction device is considered preferable to that employed on the model E and the naval mount, Mark I, in that it includes Belleville springs which are compressed on firing and permit the shock of recoil to be transmitted more directly through the trunnion bearings. It is the same in design as the mechanism used on the 12-inch, 50-caliber gun mount, plate 178, and the 16-inch howitzer mount, plate 357. Its action on the 16-inch howitzer mount has proved particularly efficient.

259. Traversing Mechanism.—Wide traverse can be secured with a mount of this type only by operating it on a curved track. The one difference between the operation of this mount and the 10-inch mount, under which the operations have been described in detail, is that the piece is both traversed and returned to the firing position by electric translating motors mounted in the extreme forward and rear trucks. This motor driven translating mechanism is shown on plate 295. The electric current is supplied from the gasoline-electric generator mounted in the car body. On this plate, it will be observed that the electric motor (20 horsepower), drives by means of a spur gear, a longitudinal shaft, which in turn drives a cross shaft by means of miter gears. This cross shaft drives by means of two sets of spur gears, two other cross shafts on the second of which are mounted three sprocket wheels. Chains connect these three sprocket wheels with other sprocket wheels on the three nearest axles. A solenoid operated clutch is provided to throw the motor out of gear in the event of an excessive overload. This translating mechanism on each truck can likewise be driven by hand by means of four handles, two on each side of the truck. Provision is made likewise for traversing the entire car body on the span bolsters in a manner similar to that employed on the 14-inch mount, model E. The details of this mechanism are shown on plates 296 to 302. A traverse of 2.5 degrees on each side of the center line is secured through the provision of a traversing table or bolster with a pivot casting rigidly bolted to it, plate 295, which at the bottom, turns in a center casting bolted rigidly to the main bolster and at the top, turns in a center casting which has guides machined on two sides, and slides in grooves

cut in a casting bolted rigidly to the car body. A nut is machined in the top of the upper center casting, in which the traversing screw turns. The ends of this screw are turned down, plain on one end and with rings at the other, plate 296, and are fitted with bearings which are a part of the casting bolted rigidly to the car body. When the car body is exactly on the center it may be locked for traveling, plate 297. On the extreme ends of the screw, are mounted sprocket wheels which are operated by chains, sprocket, pinion, and handwheels mounted on both sides of the car body, plates 298 and 299. The car body rests on the traversing table by means of two sets of rollers, plate 300, and the traversing table rests on rollers carried in the main bolster, and of a design shown on plate 302.

260. Gun Carriage.—The gun carriage is incorporated with the car body and the two are described together in the next paragraph.

261. Car Body.—The car body or main frame consists of two heavy structural steel box girders connected by deck plates and structural steel transoms. The design is shown in detail on plates 303 to 308. The cast-steel trunnion bearings equipped with antifriction devices are mounted on the tops of the side girders. The 50-kilowatt gasoline electric generator set is mounted forward between the girders, and the sleeper jacks and sleepers are assembled in the bottom of the girders.

262. Anchorage.—The anchorage system is, in general, like that of the 10-inch and 12-inch mounts and the French sliding mounts. The bearing stringers on which the mount slides are 10-inch, 40-pound I beams. Eight lines of these are bolted to the ties on the inside and outside of the rails. Six sleepers, five under the main body of the mount and one under the rear span bolster, transfer the weight of the mount to the stringers and transmit the firing load. Each sleeper is made up of three heavy timbers bolted together and is supported on two jacks for vertical movement. The design of the jacks and sleepers is shown on plates 309 and 310. The sleeper under the rear span bolster is provided with steel shoes which bear directly on the rails. It is ordinarily estimated that about half of the weight of the mount is transferred to these sleepers in preparation for firing.

263. Trucks.—The trucks are special five-axle locomotive type with 6 by 11 inch inside journals and 33-inch cast steel wheels and structural steel side frames, deck plates, and transoms, plates 311 and 312. Hand and air brakes are installed on the exterior trucks, plate 313.

264. Ammunition Supply System.—Ammunition is transported from the ammunition car to the mount by means of a shuttle car, or transbordeur, of the design shown on plates 314 and 315. This transbordeur carries five full rounds of ammunition. The two ends of the top of the transbordeur are made up of hinged wings, which

are swung around and locked to the main frame in traveling. The transbordeur is equipped with an ammunition truck, which can be run forward on the forward wings by means of a hand-translating mechanism until it is under the jib crane mounted on the rear of the mount, plate 287. The projectile is transferred by this crane to another truck on the loading platform. This second truck has a tray of such length that when the truck is moved to the forward end of the loading rail and locked in place, the tray projects into the breech of the gun. The projectile is rammed by hand. Ammunition cars of the same design as those used with 8-inch guns, plate 106, but with special fixtures for this size and weight projectile, were to be used with this mount.

Plate 285

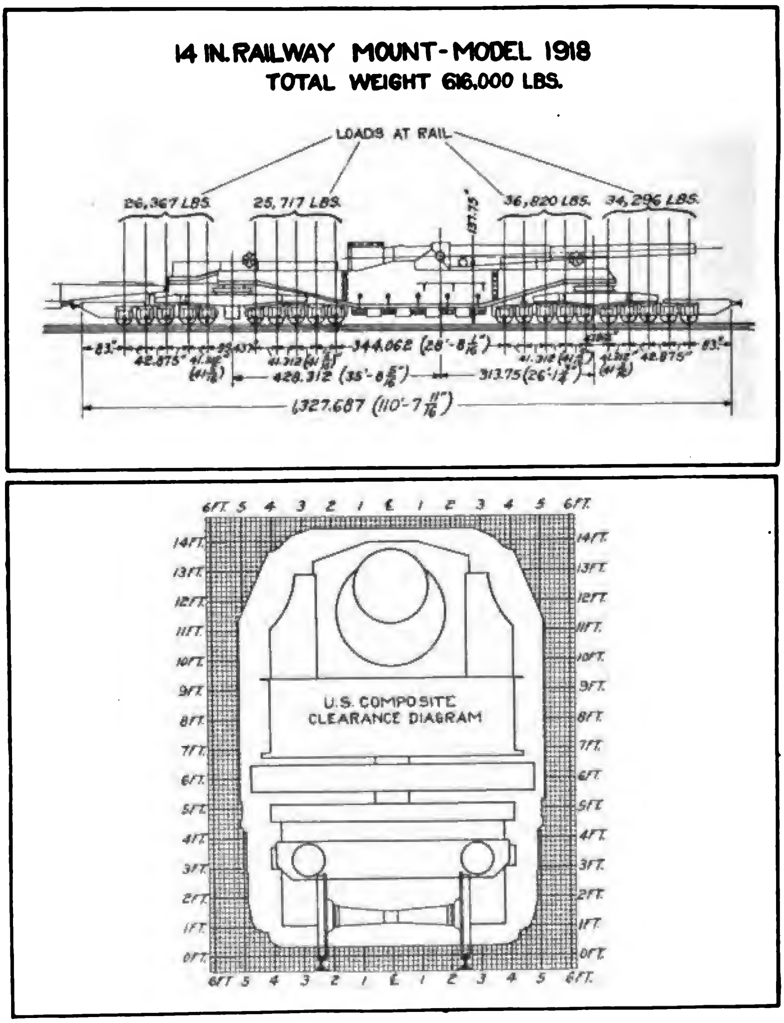


PLATE 288

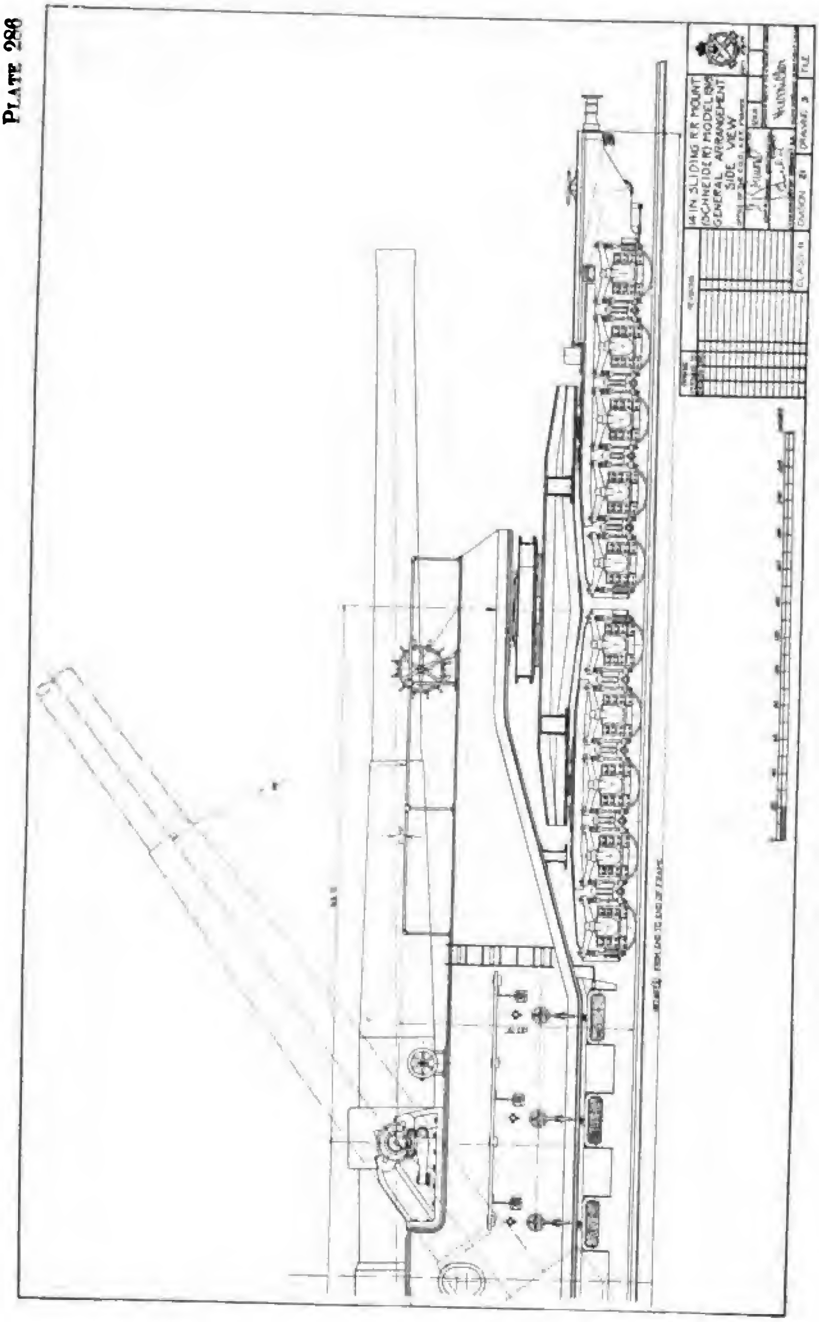


PLATE 287

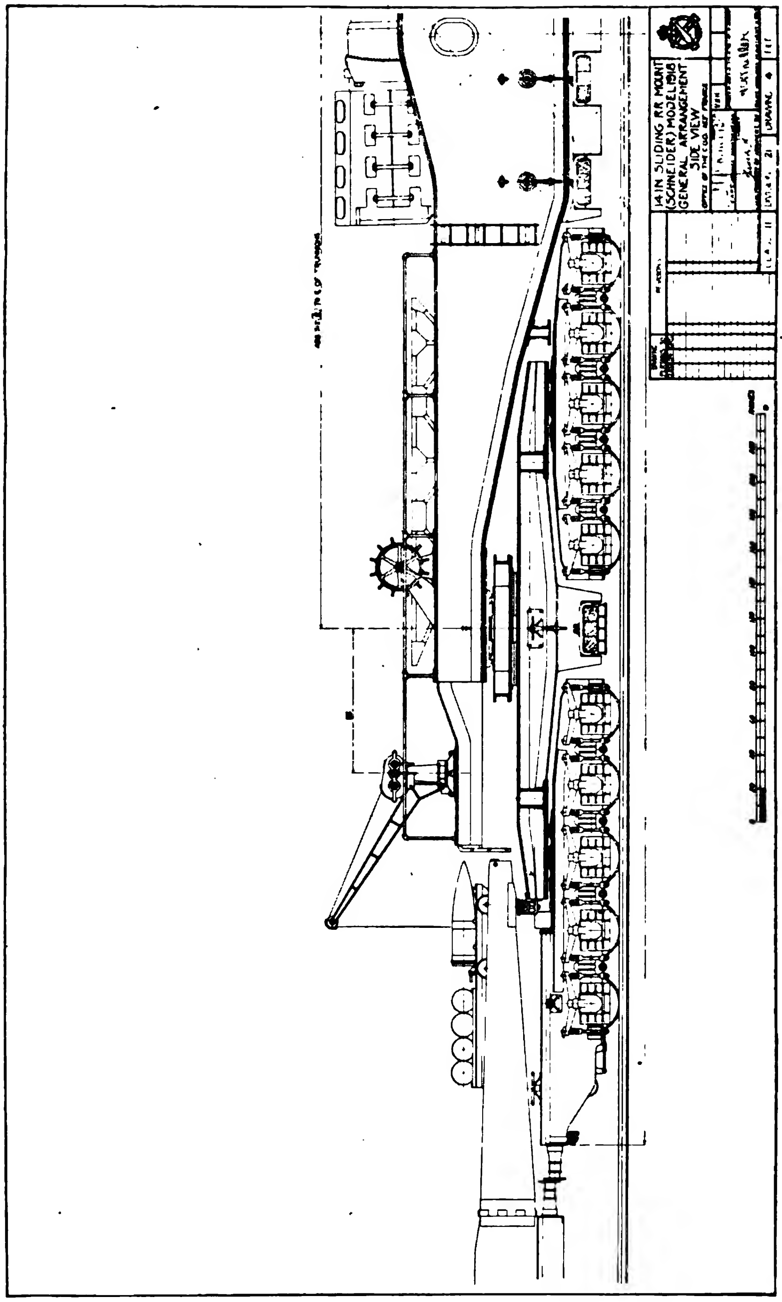

14 IN SLIDING RR MOUNT
(SCHNEIDER) MODEL 1918
GENERAL ARRANGEMENT
SIDE VIEW

PLATE 288

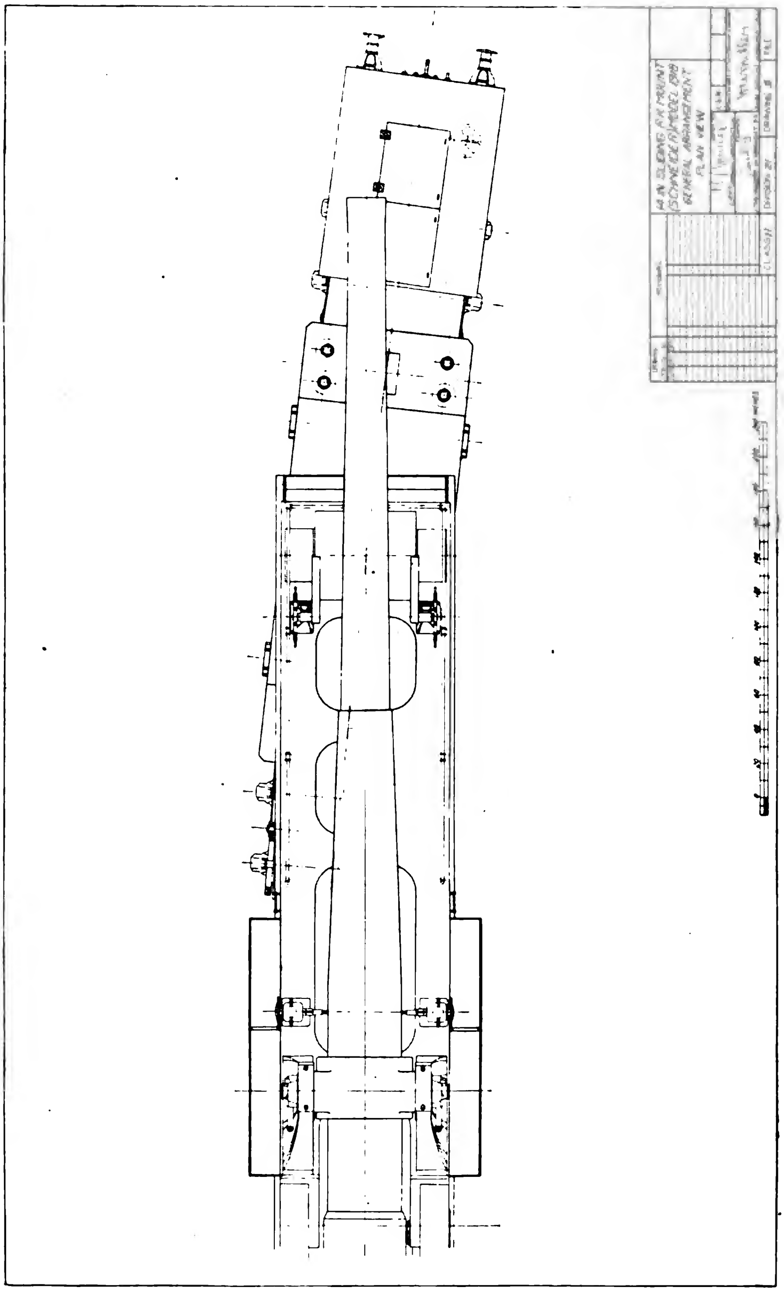


PLATE 289

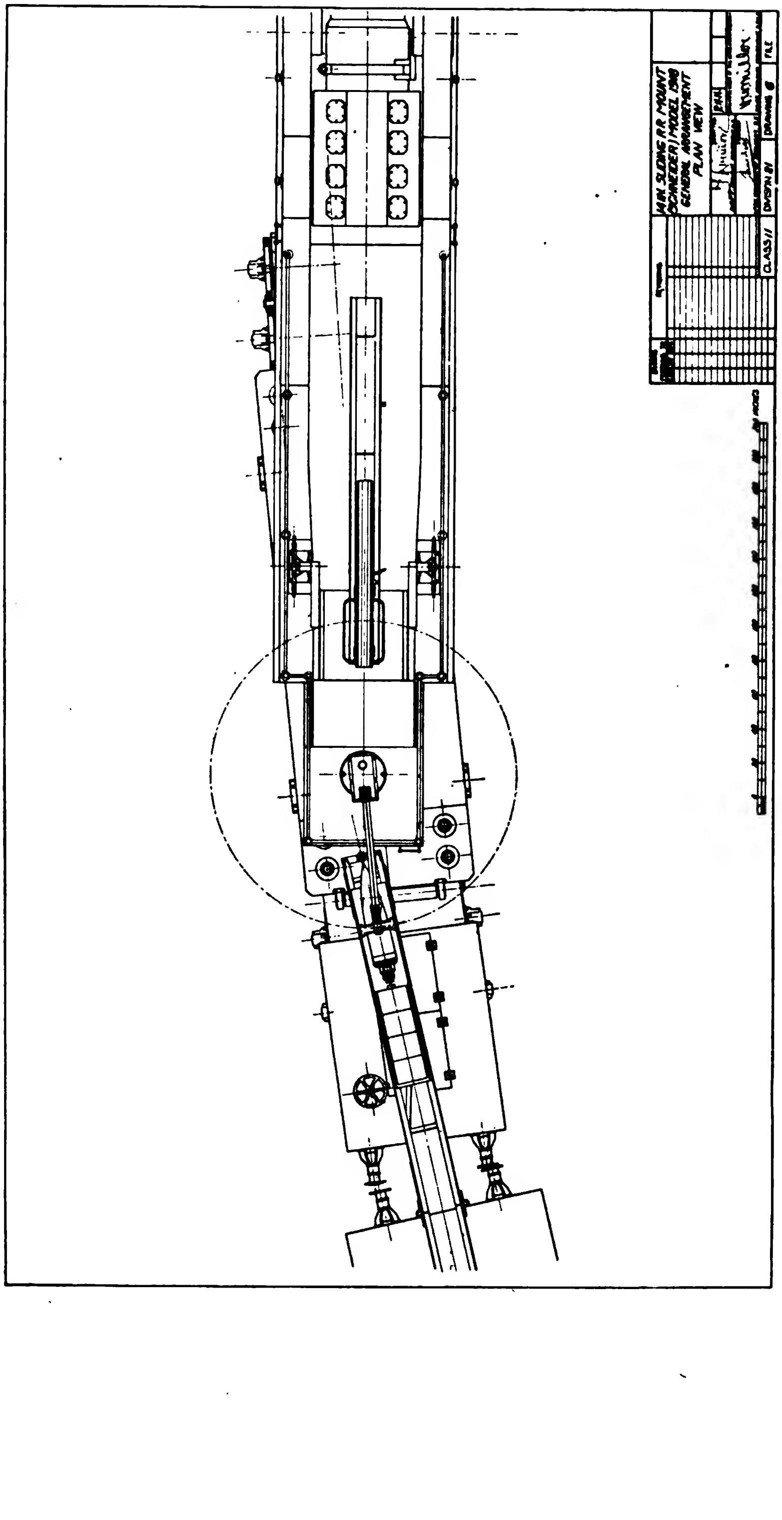
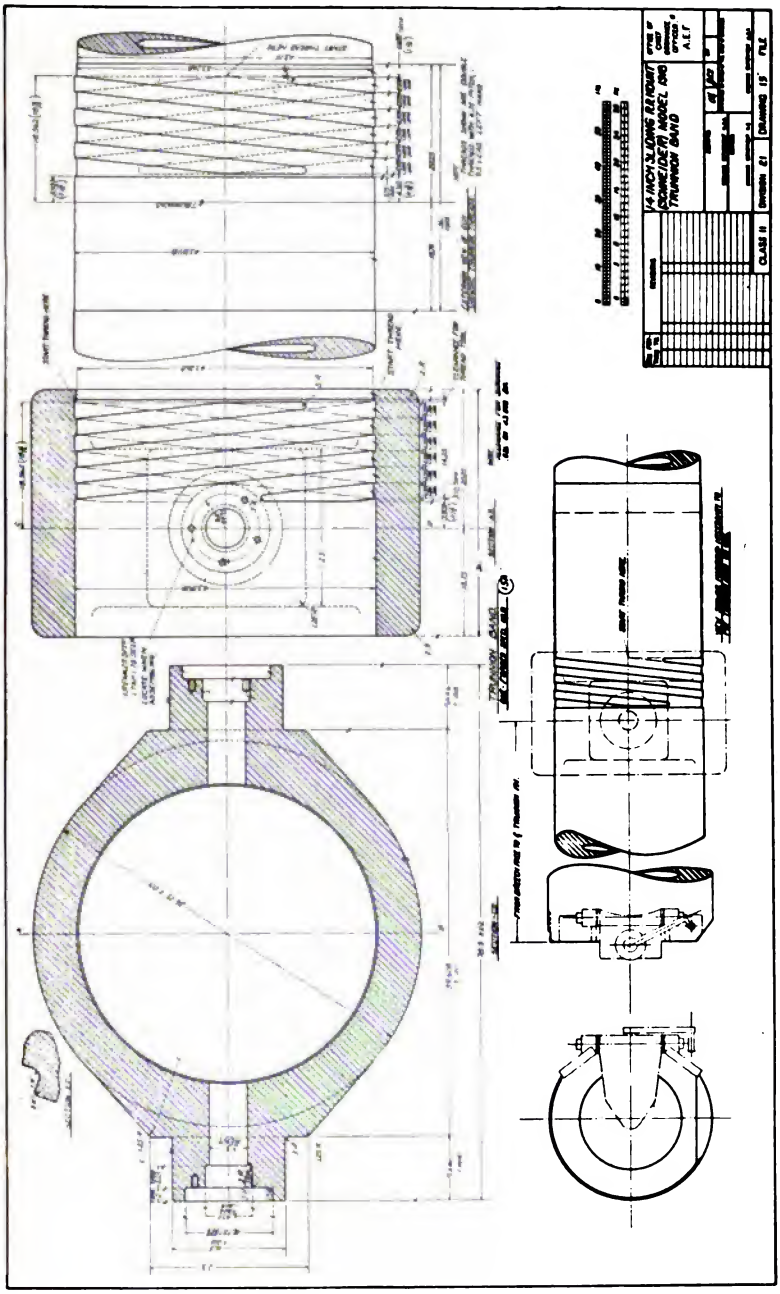


PLATE 290


14 INCH 3L(ONG) R.R. MOUNT (SCHNEIDER) MODEL 1916
TRUNNION BAND
A.E.F.
CLASS 11
DIVISION 21
DRAWING 15
FILE

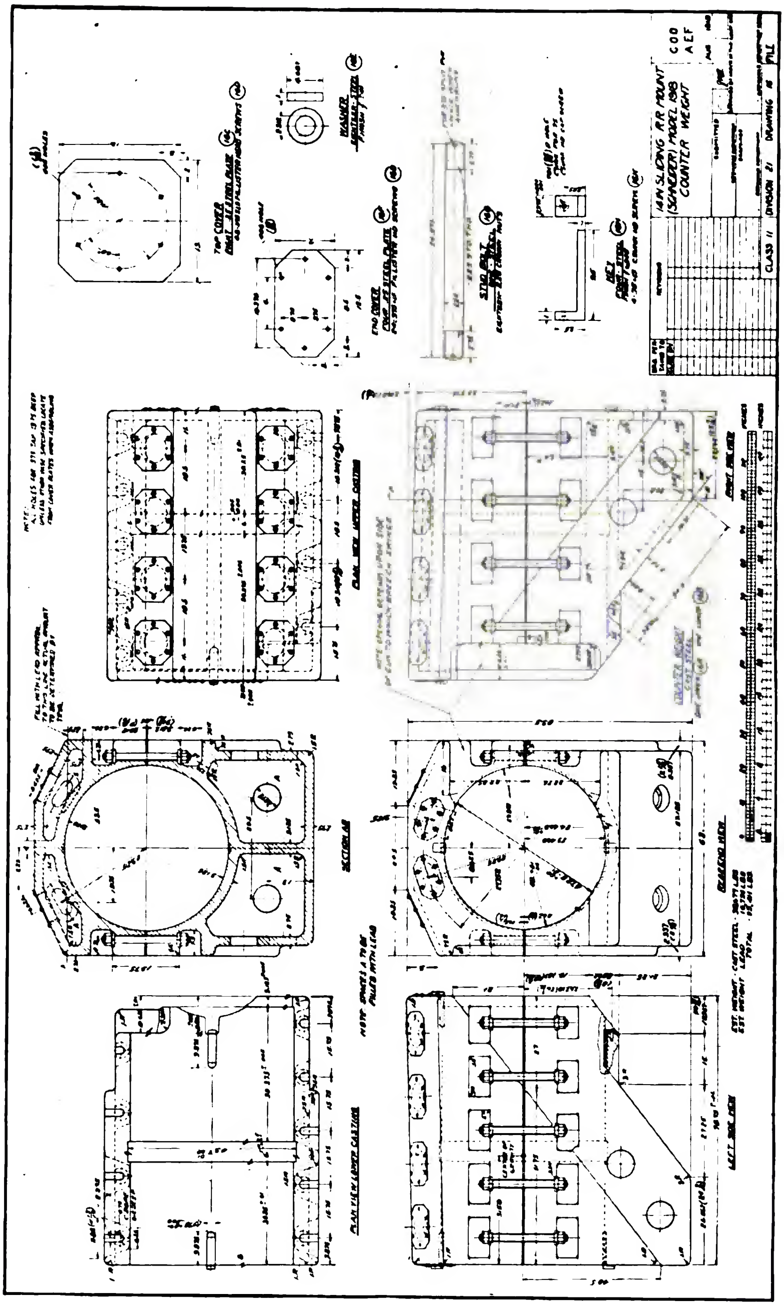


Plate 291

PLATE 292

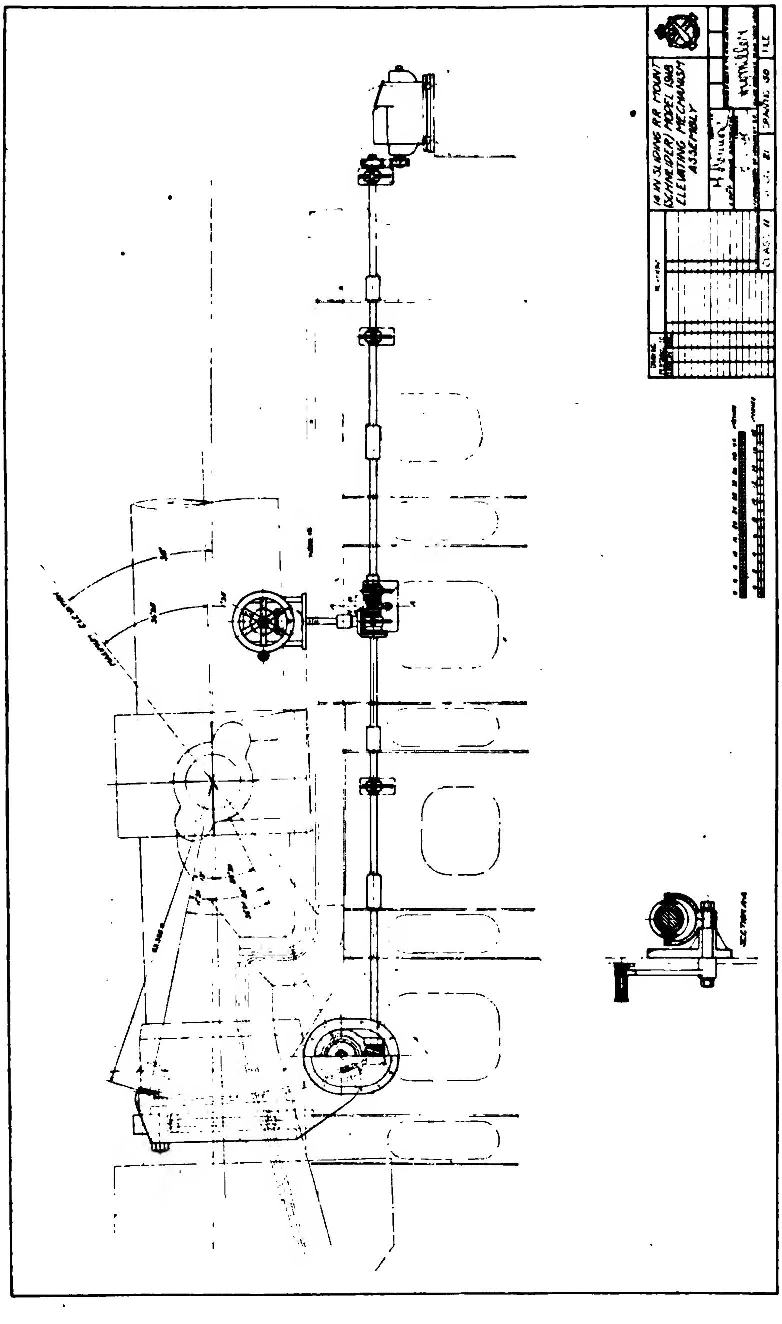

14 IN. SLIDING R.R. MOUNT (SCHNEIDER) MODEL 1918 ELEVATING MECHANISM ASSEMBLY
CLASS 11
SECTION A-A

PLATE 283

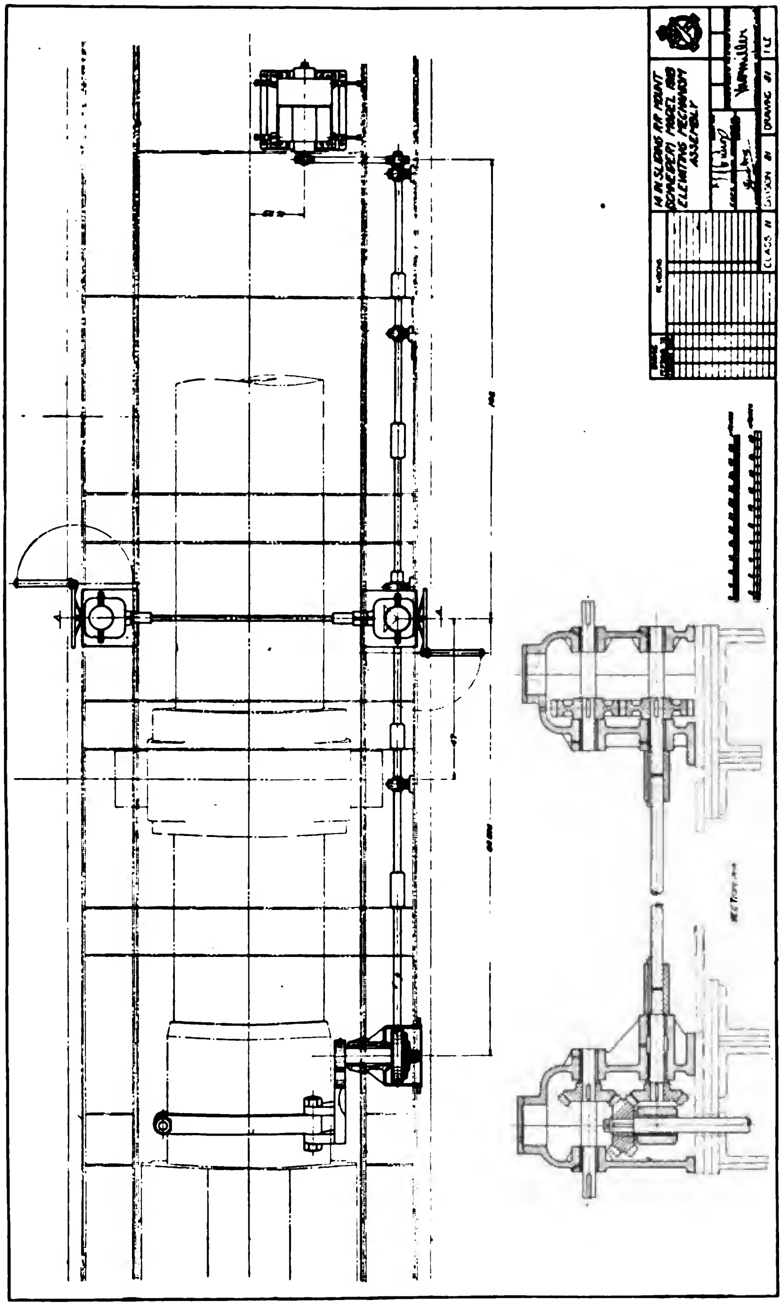


PLATE 294

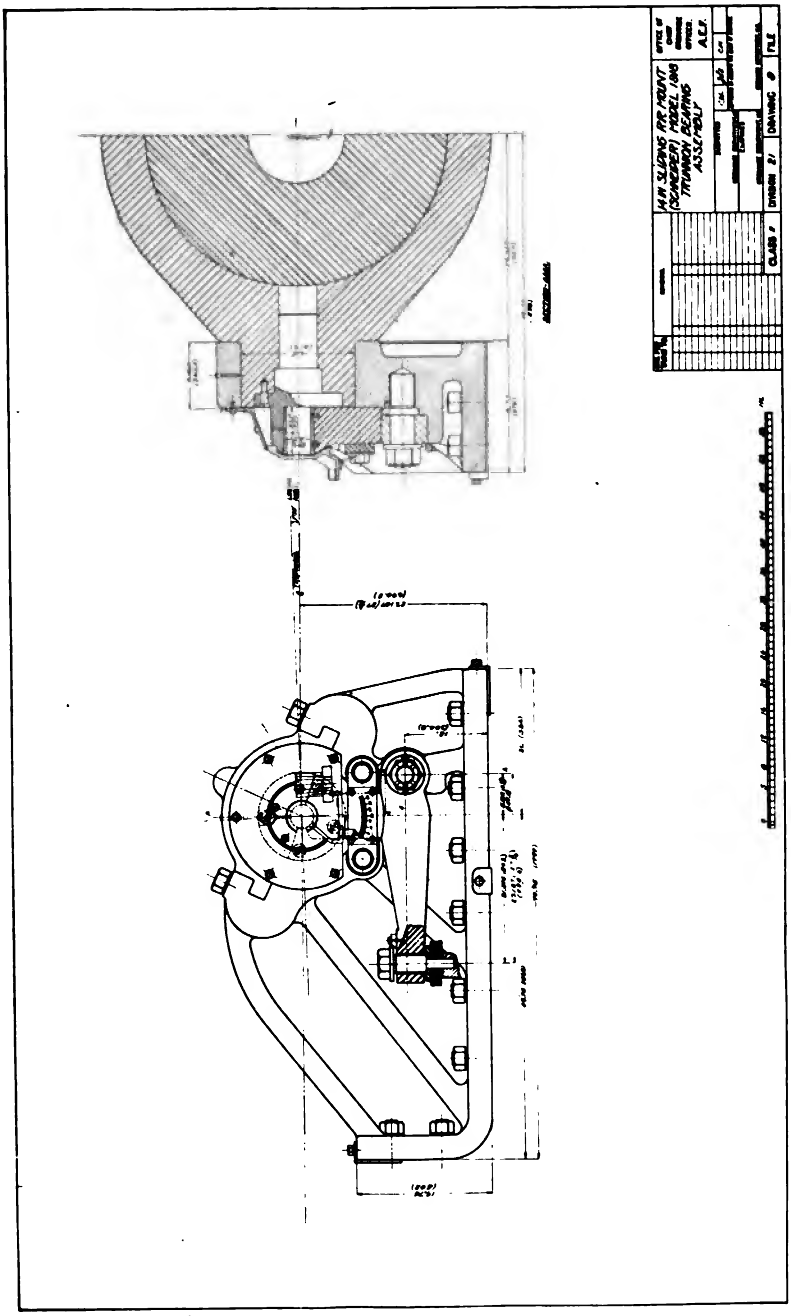


PLATE 285

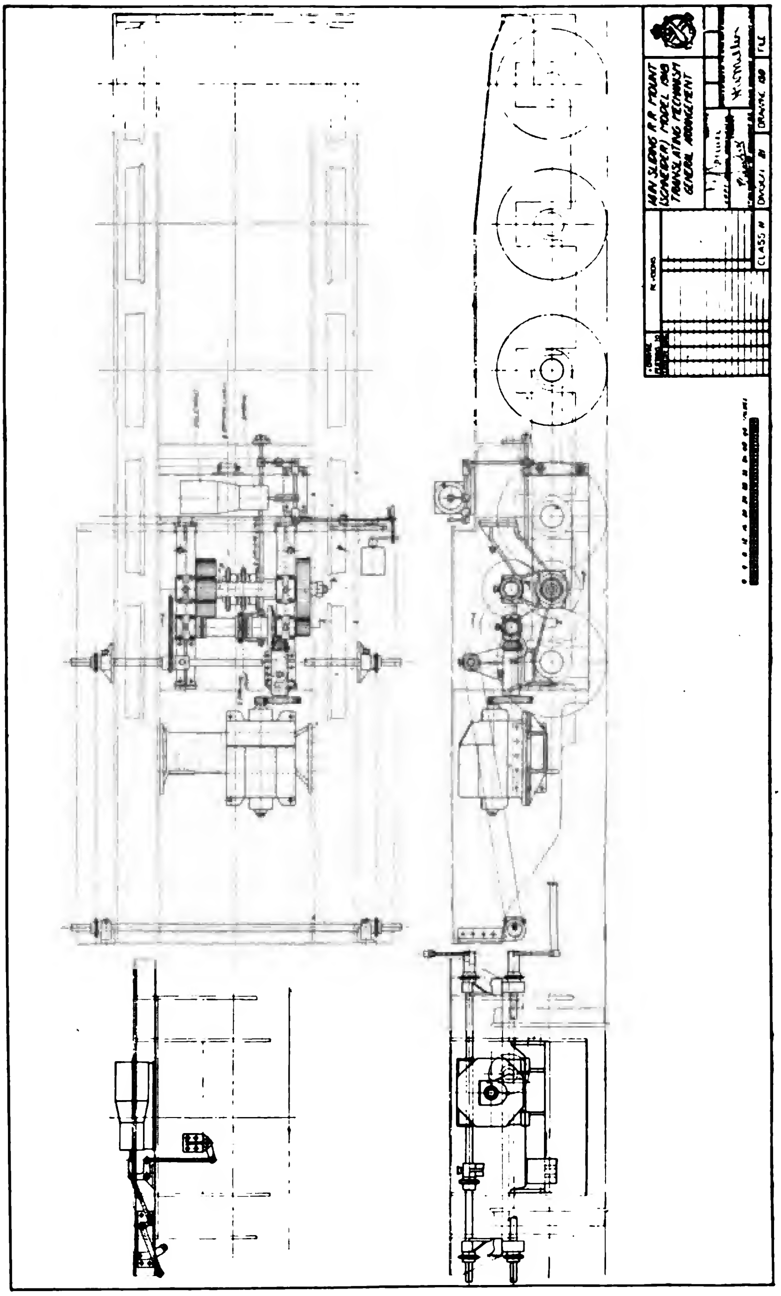
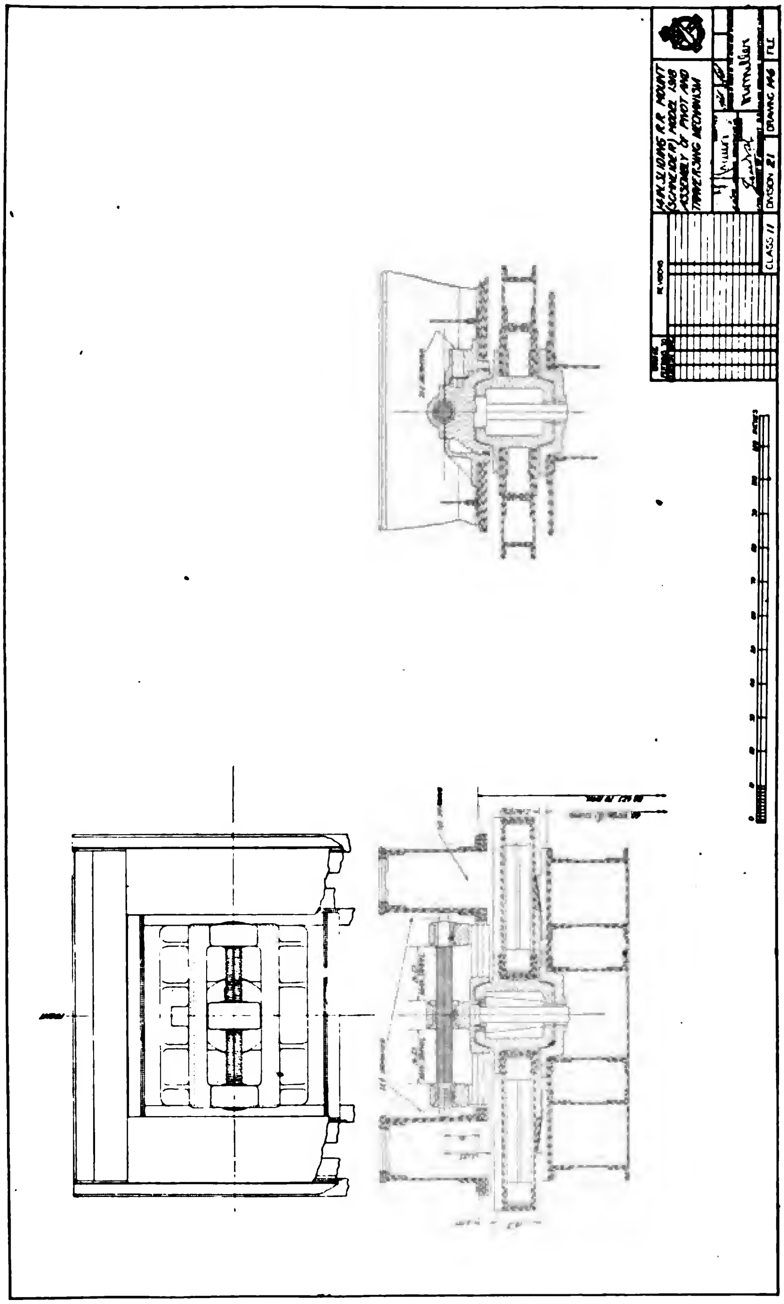

MAIN SLIDING R.R. MOUNT
(SCHNEIDER) MODEL 1918
TRANSLATING MECHANISM
GENERAL ARRANGEMENT
CLASS
DRAWING
FILE

PLATE 296



14 IN. SLIDING R.R. MOUNT (SCHNEIDER) MODEL 1918 ASSEMBLY OF PIVOT AND TRAVERSING MECHANISM
CLASS 11
DIVISION 21
DRAWING NO
FILE

PLATE 297

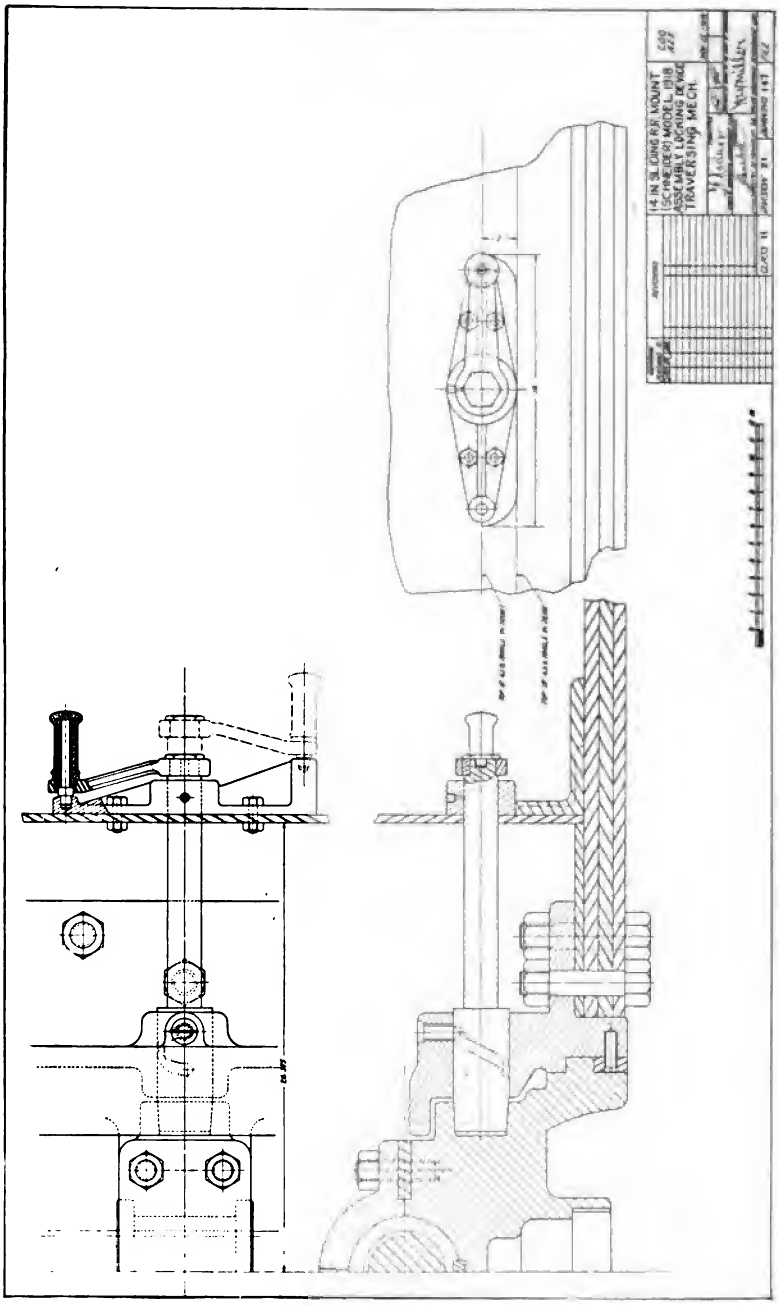

14 IN. SLIDING R.R. MOUNT
(SCHNEIDER) MODEL 1918
ASSEMBLY LOCKING DEVICE
TRAVERSING MECH.

PLATE 298

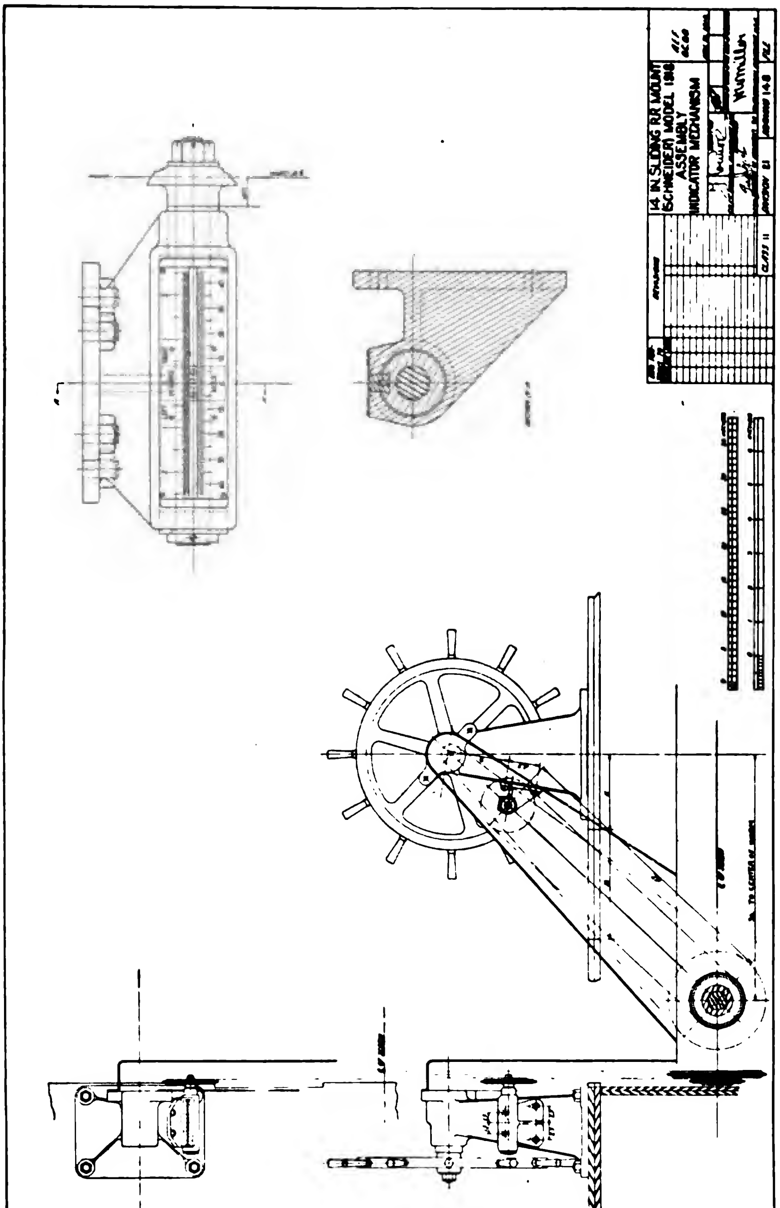

14 IN. SLIDING R.R. MOUNT
(SCHNEIDER) MODEL 1918
ASSEMBLY
INDICATOR MECHANISM

PLATE 299

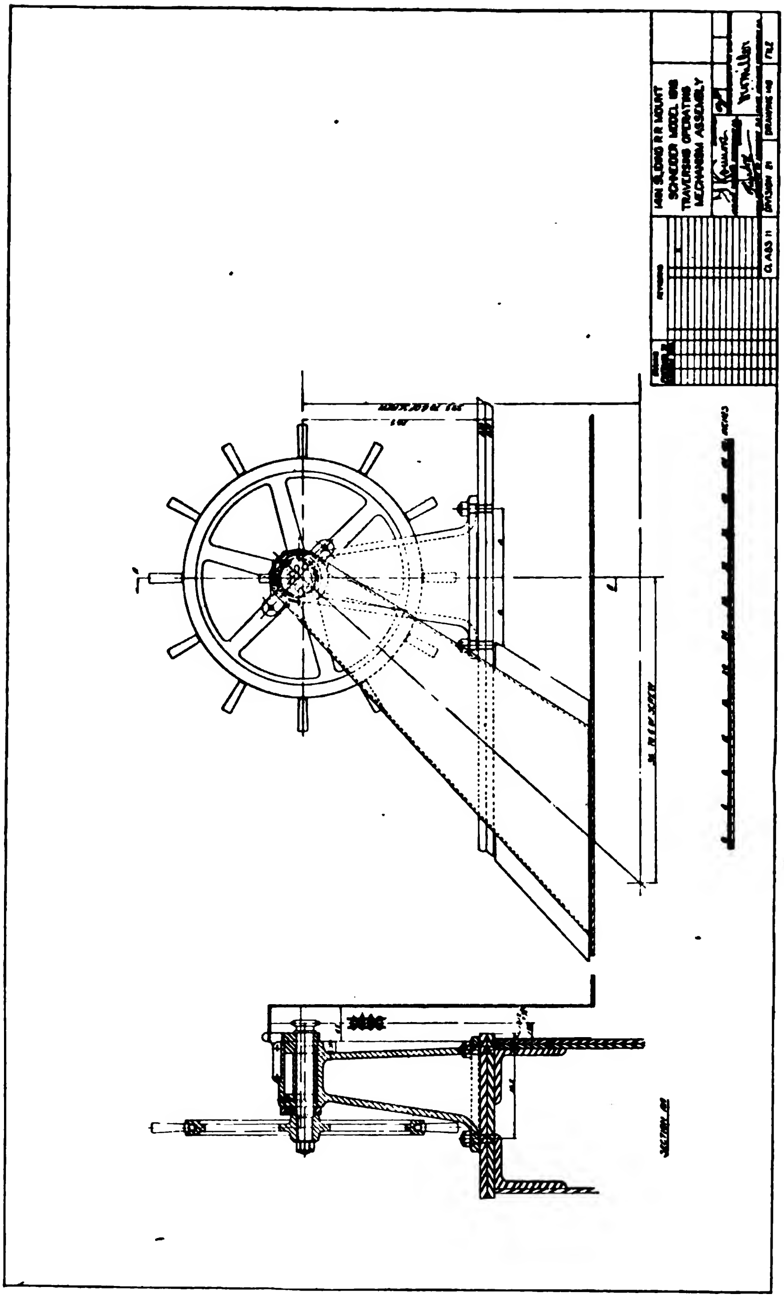

14IN SLIDING R R MOUNT
SCHNEIDER MODEL 1918
TRAVERSING OPERATING
MECHANISM ASSEMBLY
CLASS 11
DIVISION 21
DRAWING NO
FILE

PLATE 300

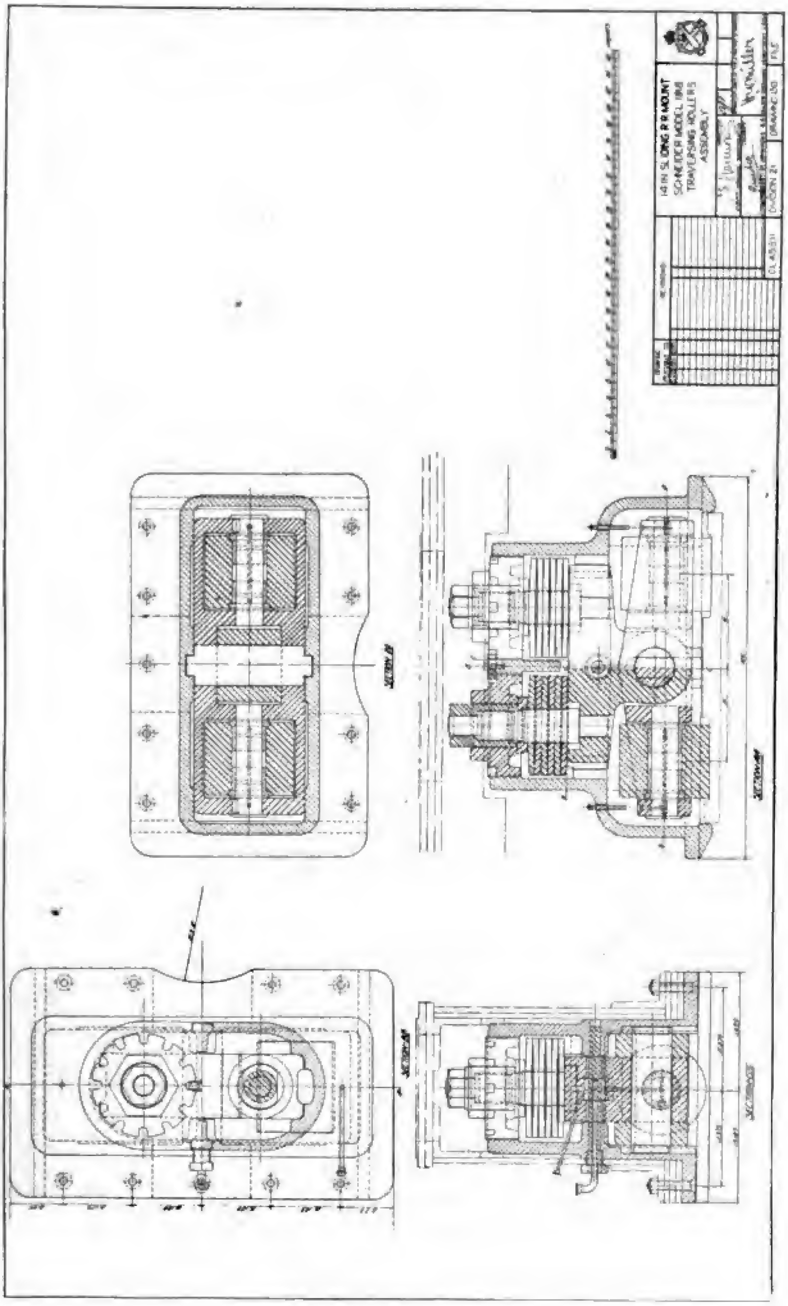

14 IN. SLIDING R R MOUNT
SCHNEIDER MODEL 1918
TRAVERSING ROLLERS
ASSEMBLY

PLATE 301

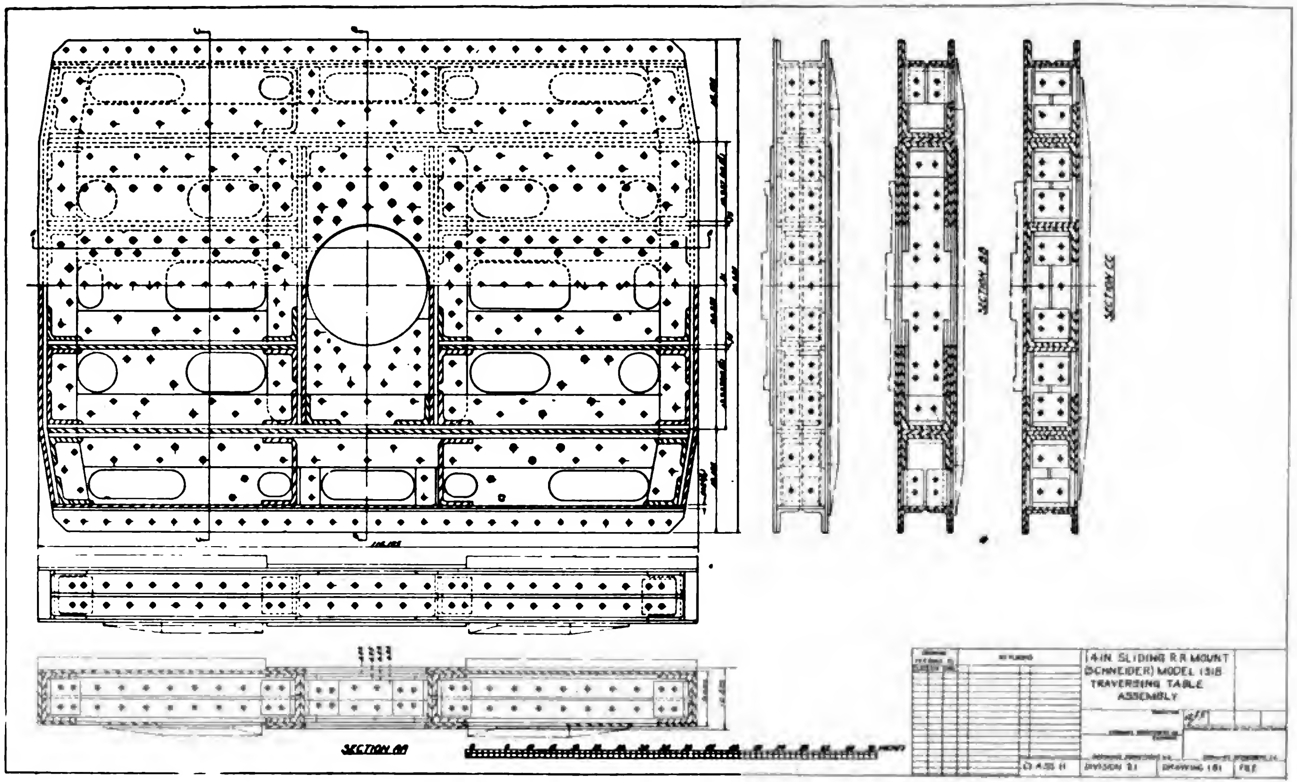

SECTION BB
SECTION CC
SECTION AA
14-IN. SLIDING R.R. MOUNT
(SCHNEIDER) MODEL 1918
TRAVERSING TABLE
ASSEMBLY
CLASS H
DIVISION 21
DRAWING 181
FILE

PLATE 302

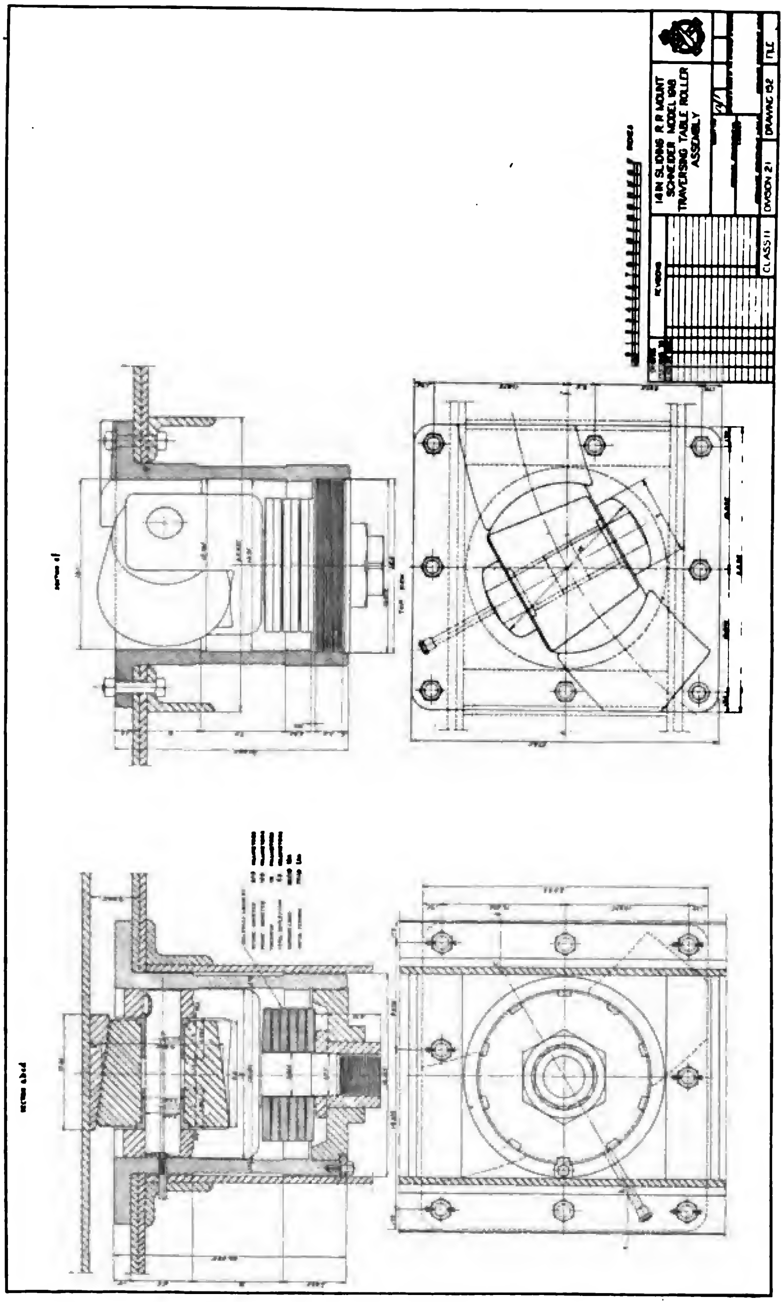

14 IN SLIDING R R MOUNT
SCHNEIDER MODEL 1918
TRAVERSING TABLE ROLLER
ASSEMBLY
CLASS 11
DIVISION 21
DRAWING 132
TLC

PLATE 303

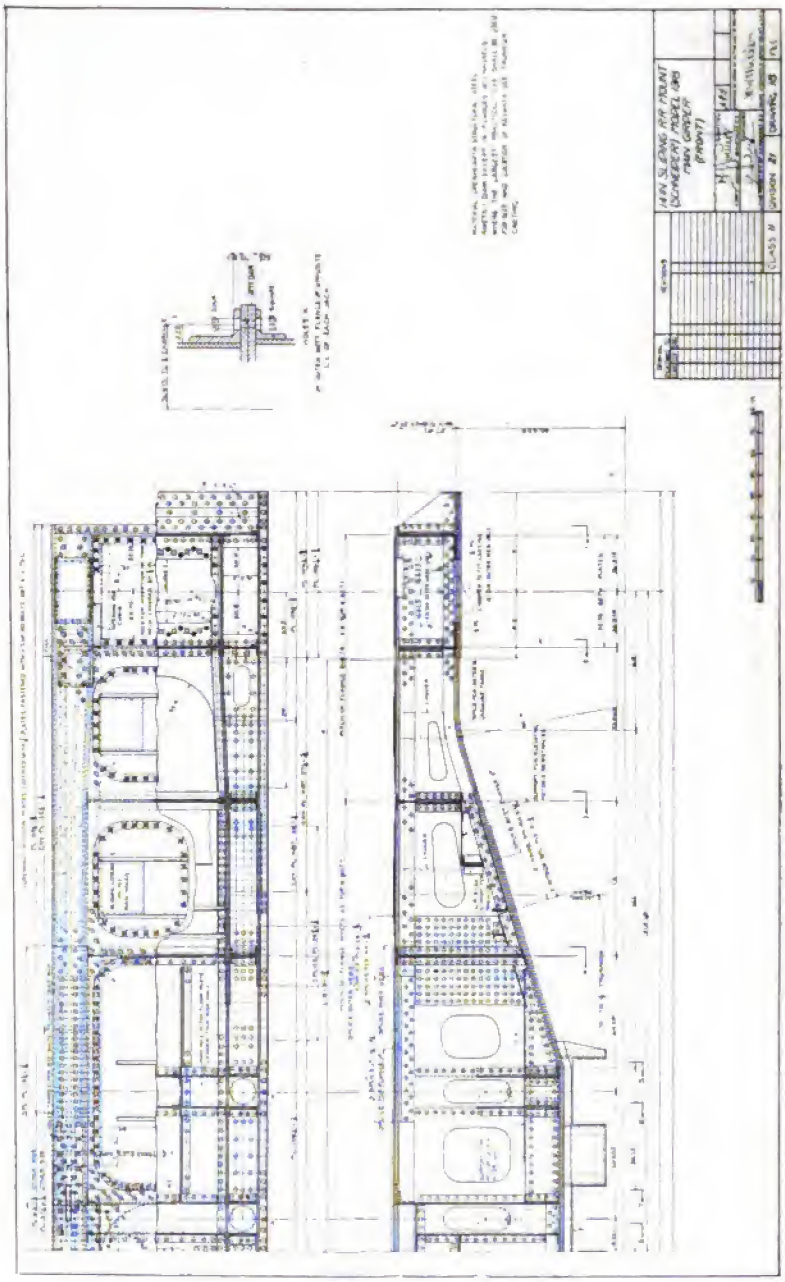


PLATE 304

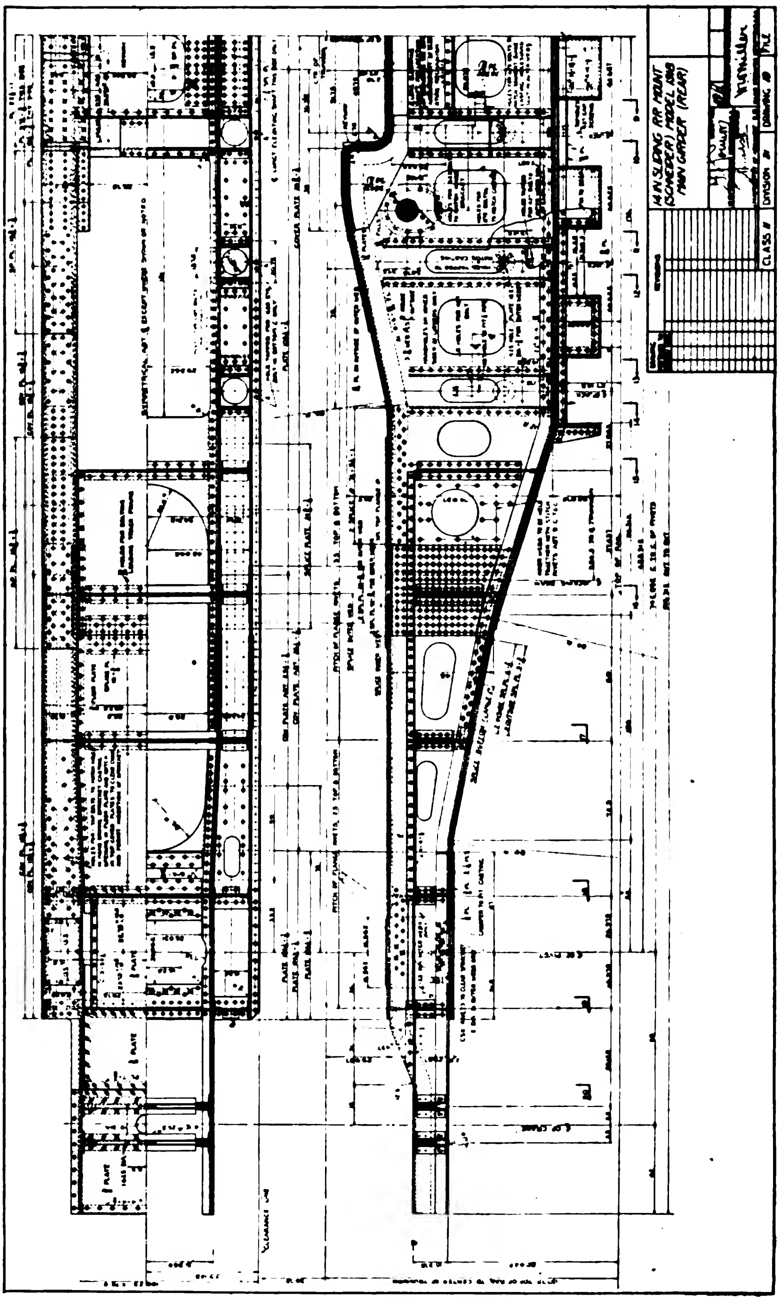

14 IN SLIDING RR MOUNT (SCHNEIDER) MODEL 1918 MAIN GIRDER (REAR)
CLASS
DIVISION
DRAWING
FILE

PLATE 305

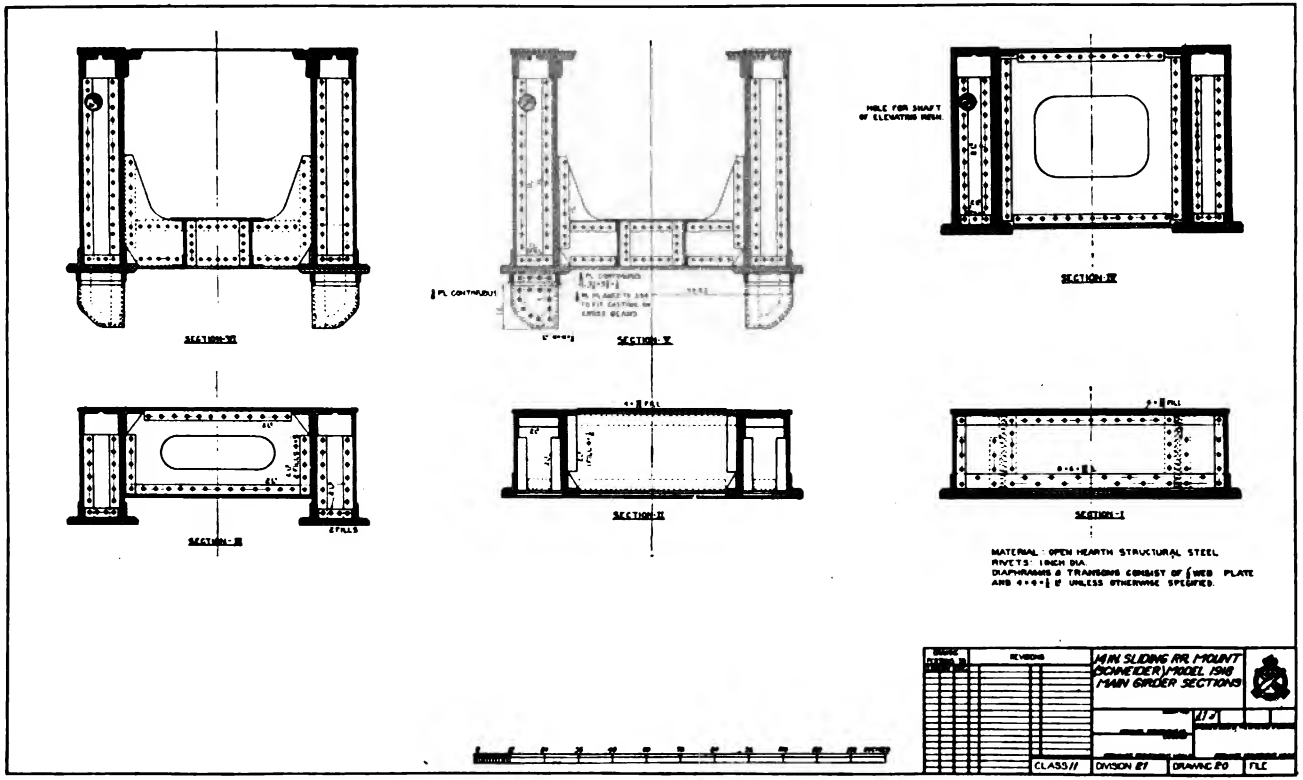

SECTION-VI
SECTION-V
SECTION-IV
SECTION-III
SECTION-II
SECTION-I
HOLE FOR SHAFT OF ELEVATING MECH.
MATERIAL: OPEN HEARTH STRUCTURAL STEEL
RIVETS: 1 INCH DIA.
DIAPHRAGMS & TRANSOMS CONSIST OF WEB PLATE AND 4×4×½ L UNLESS OTHERWISE SPECIFIED.
SLIDING RR. MOUNT (SCHNEIDER) MODEL 1918 MAIN GIRDER SECTIONS
REVISIONS
CLASS 11
DIVISION 27
DRAWING 20
FILE

PLATE 306

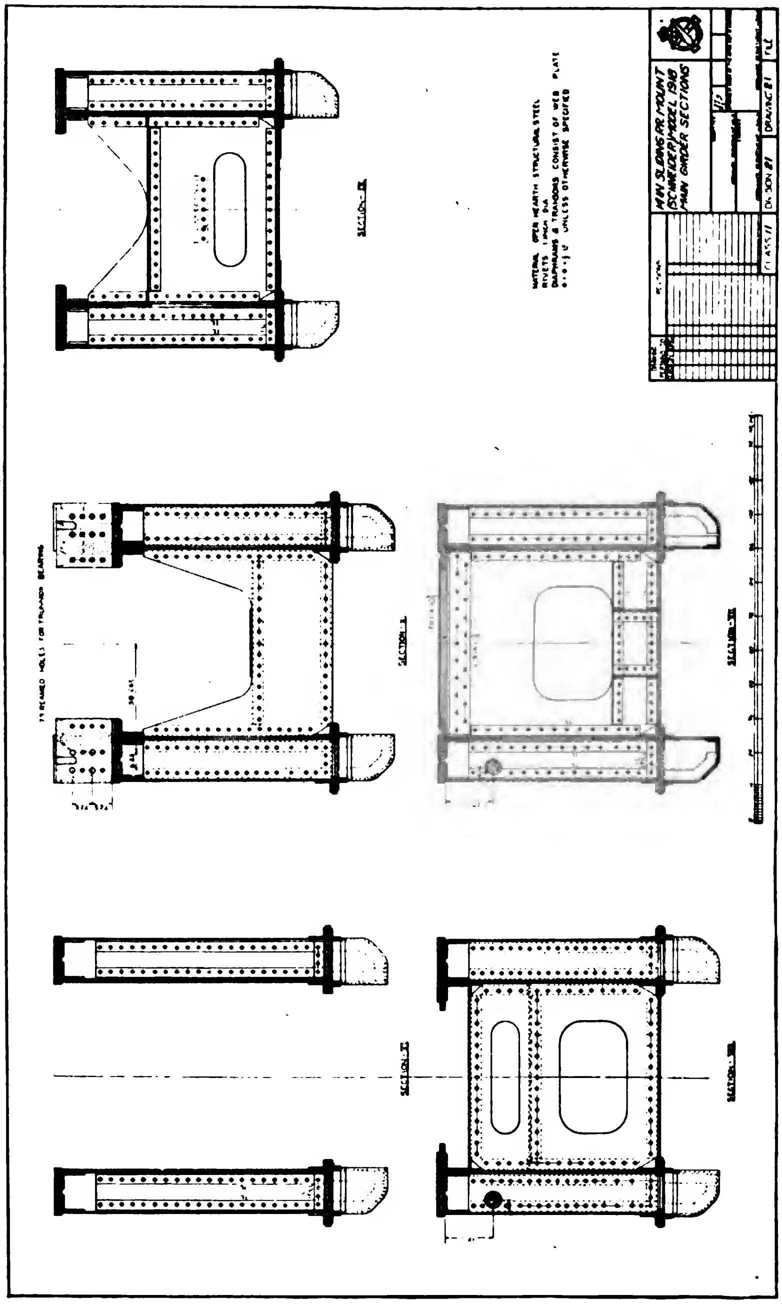

MK IV SLIDING PR MOUNT
(SCHNEIDER) MODEL 1918
MAIN GIRDER SECTIONS

PLATE 307

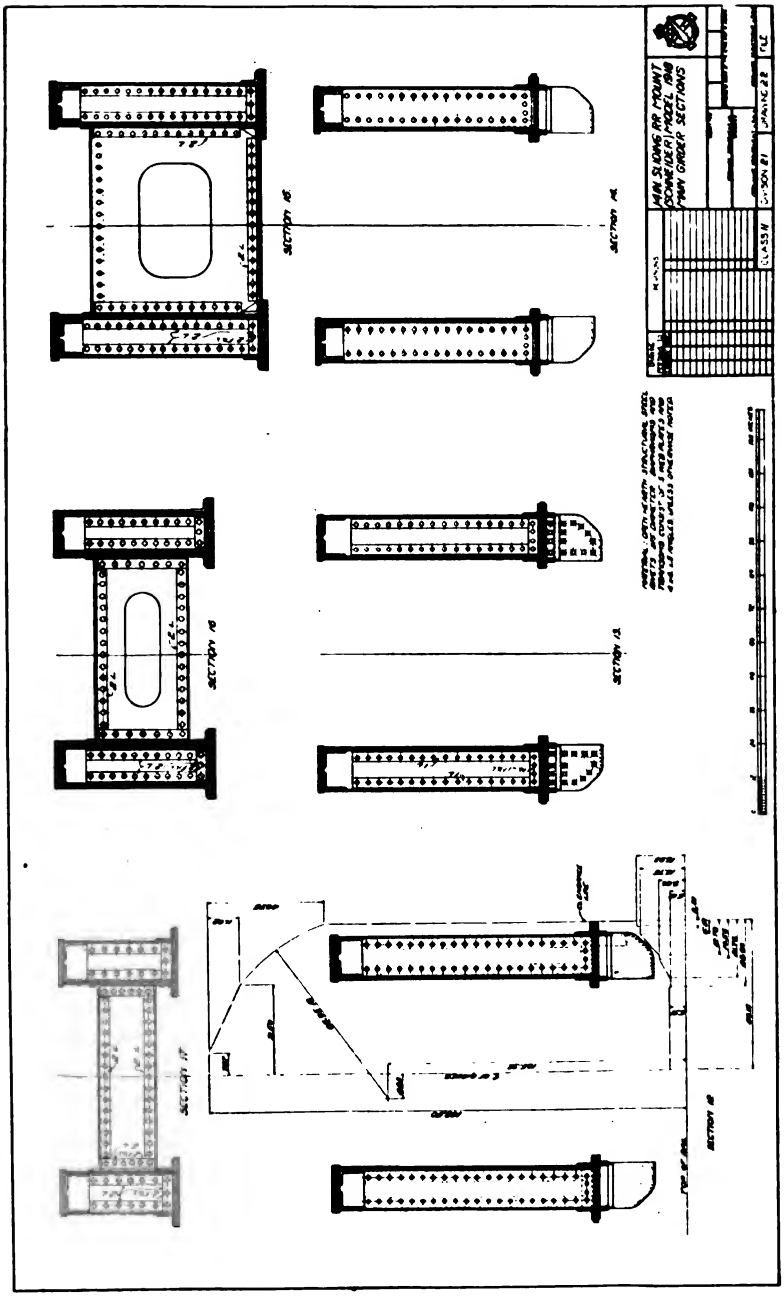

MAIN SLIDING RR MOUNT
(SCHNEIDER) MODEL 1918
MAIN GIRDER SECTIONS
SECTION 15
SECTION 14
SECTION 16
SECTION 13
SECTION 17
SECTION 18

PLATE 308

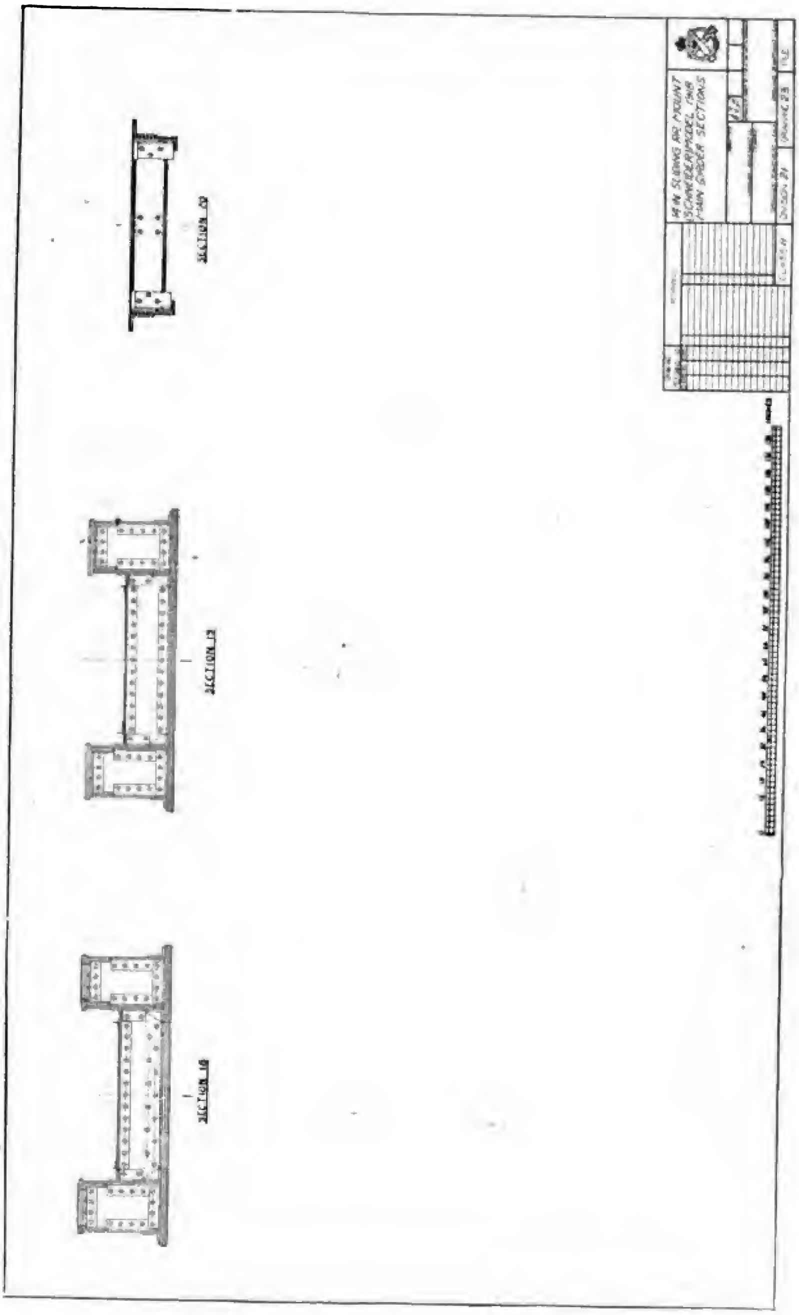

14 IN. SLIDING RY. MOUNT
MAIN GIRDER SECTIONS
SECTION 18
SECTION 19
SECTION 20

PLATE 309

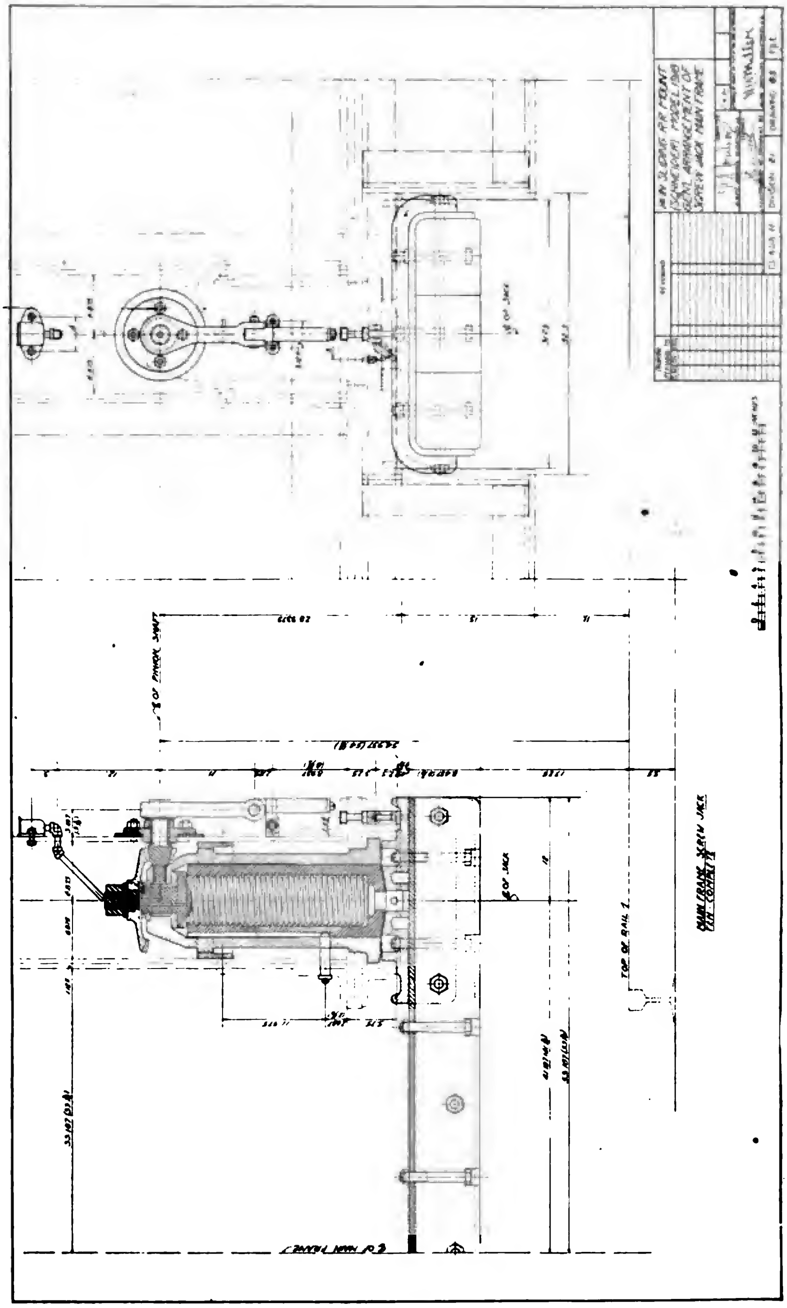


Plate 310

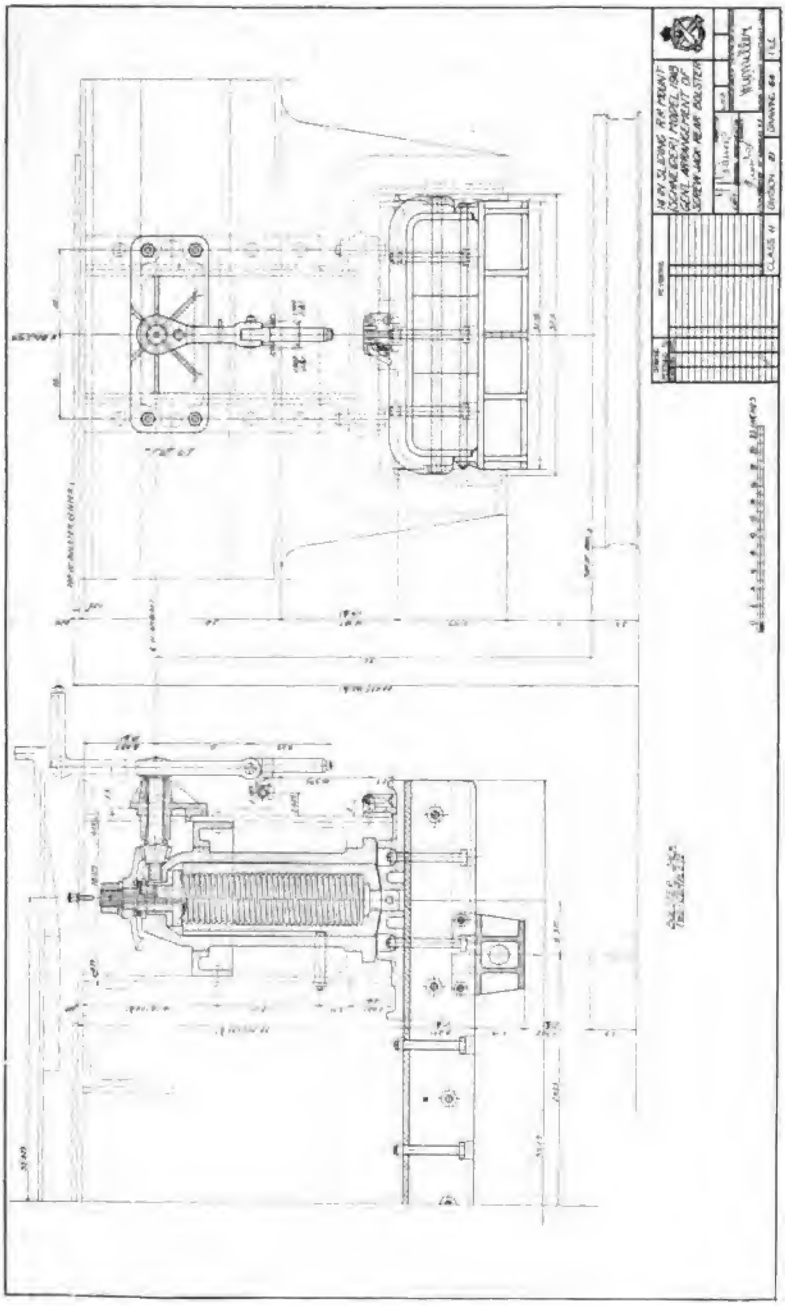

14 IN SLIDING R.R. MOUNT
(SCHNEIDER) MODEL 1918
GENL ARRANGEMENT OF
SCREW JACK NEAR BOLSTER
CLASS 14
DIVISION 81
DRAWING 64

PLATE 311

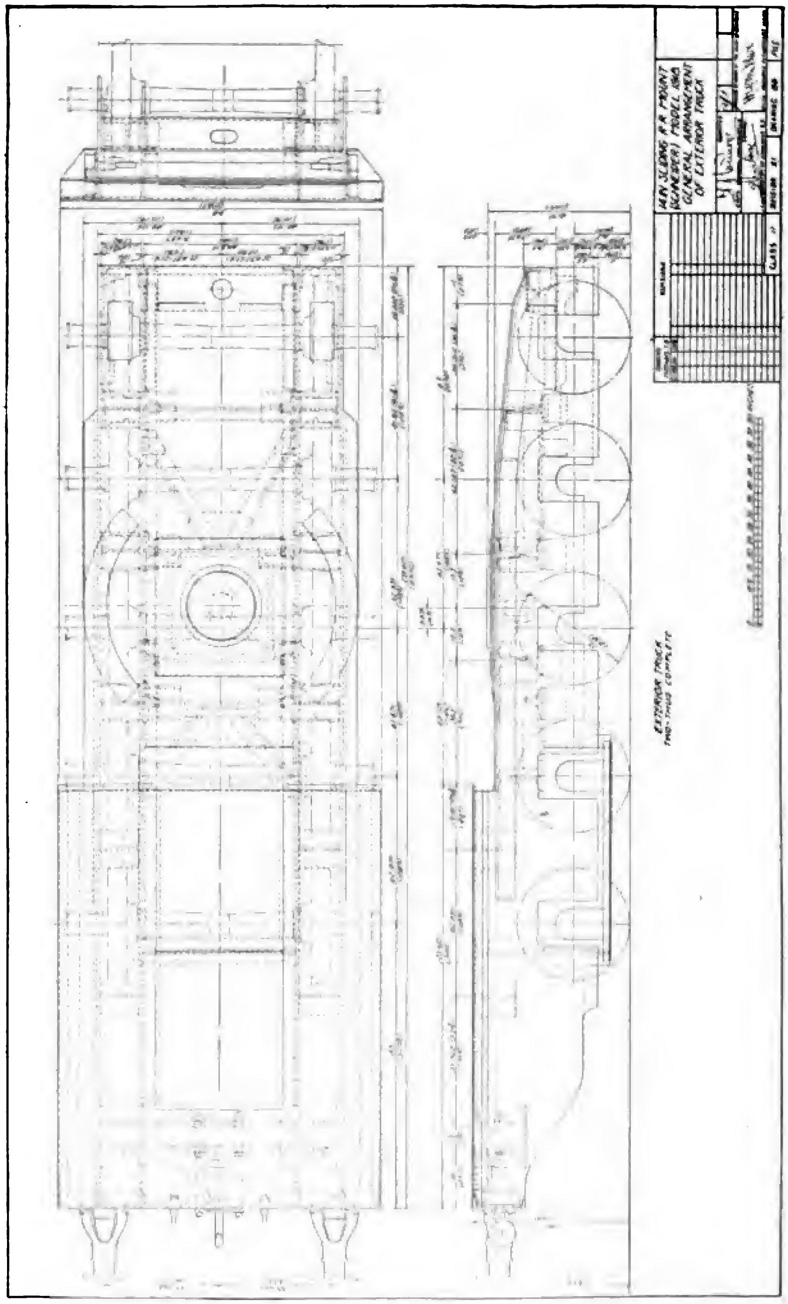


Plate 312

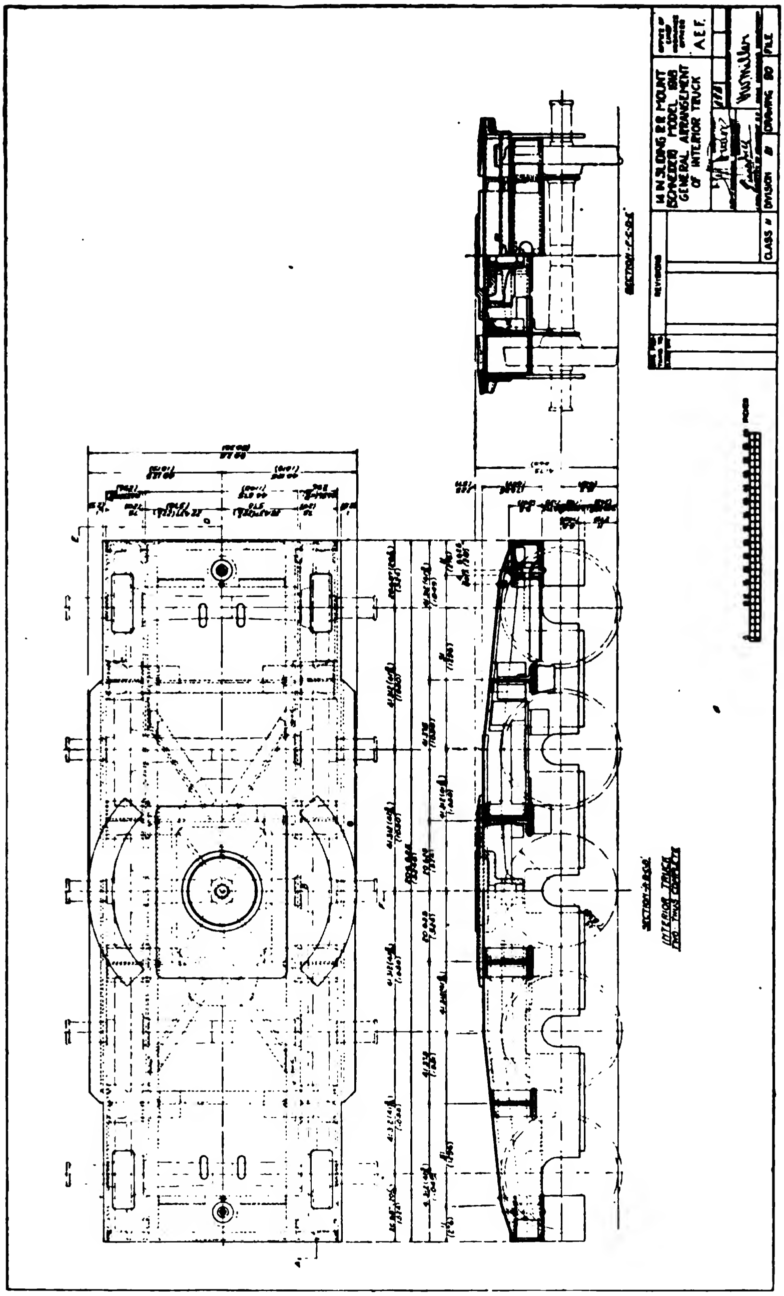

14 IN. SLIDING R.R. MOUNT (SCHNEIDER) MODEL 1918 GENERAL ARRANGEMENT OF INTERIOR TRUCK
A.E.F.
REVISIONS
CLASS
DIVISION
DRAWING
FILE

PLATE 313

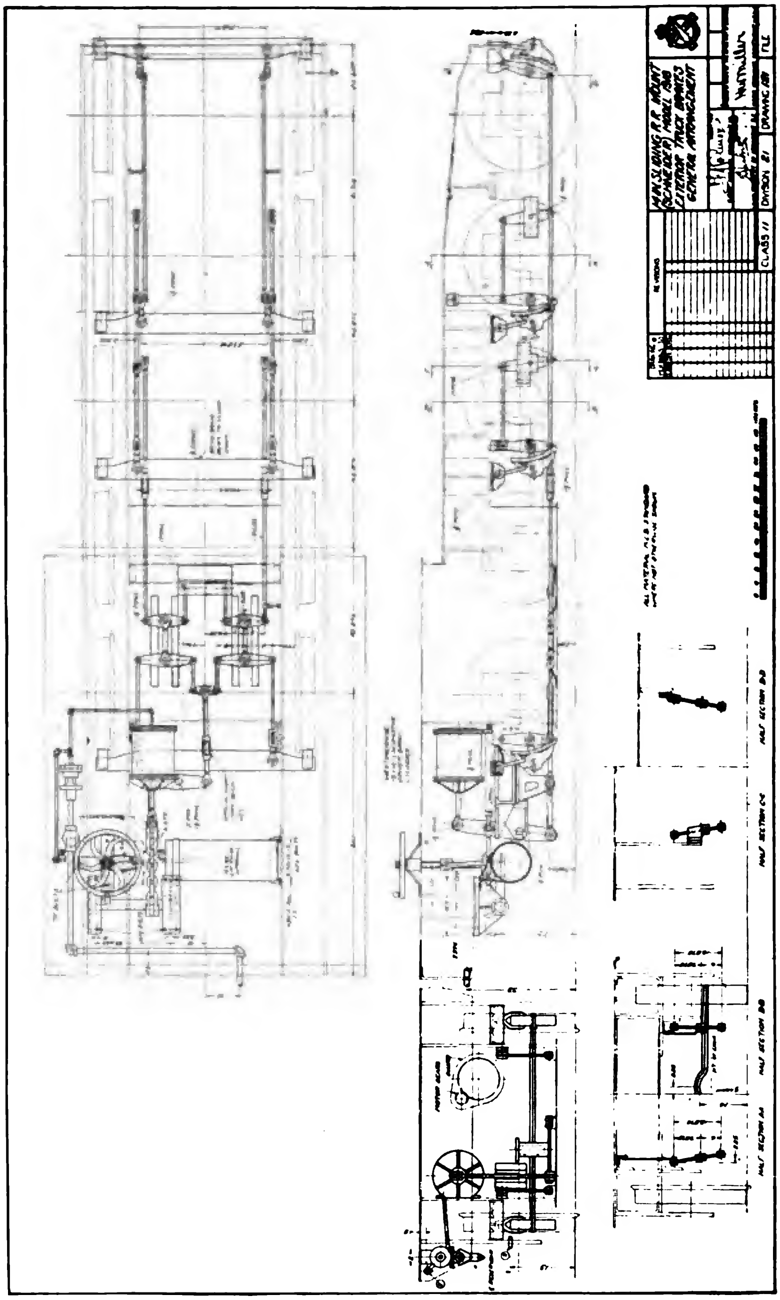


PLATE 314

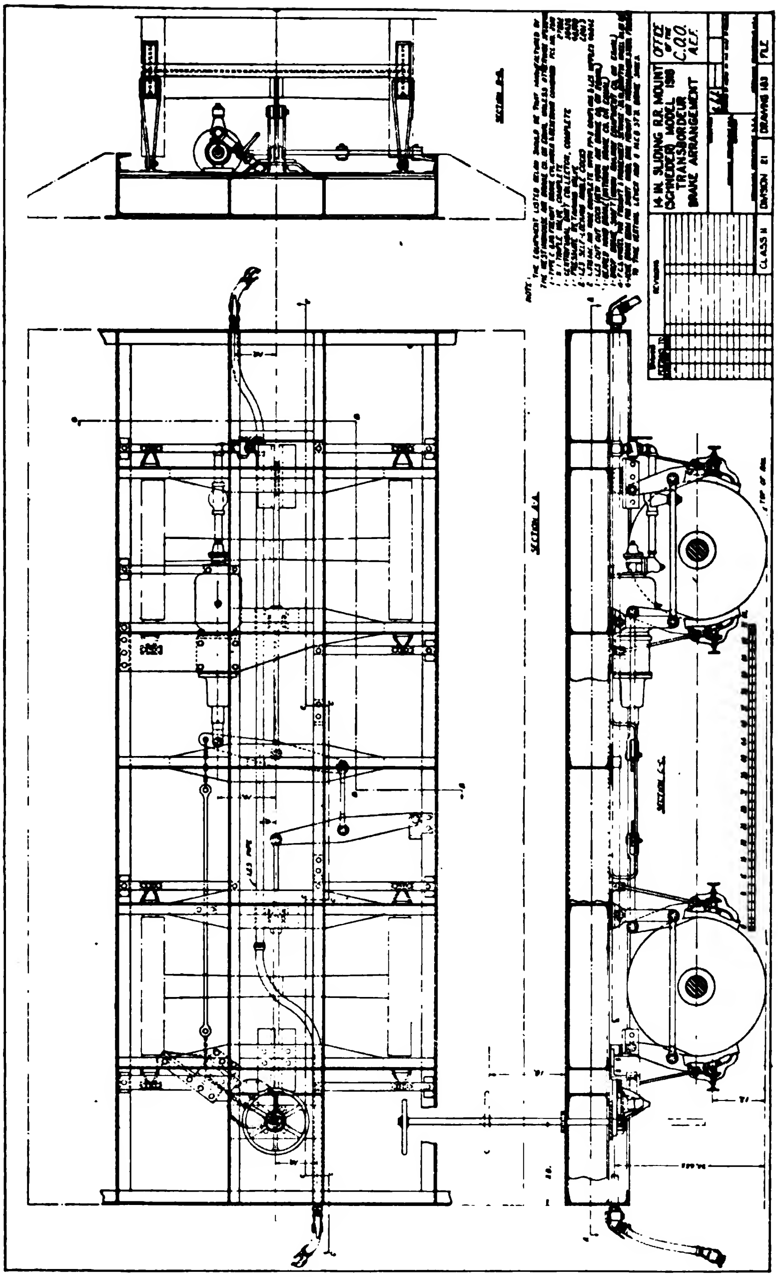
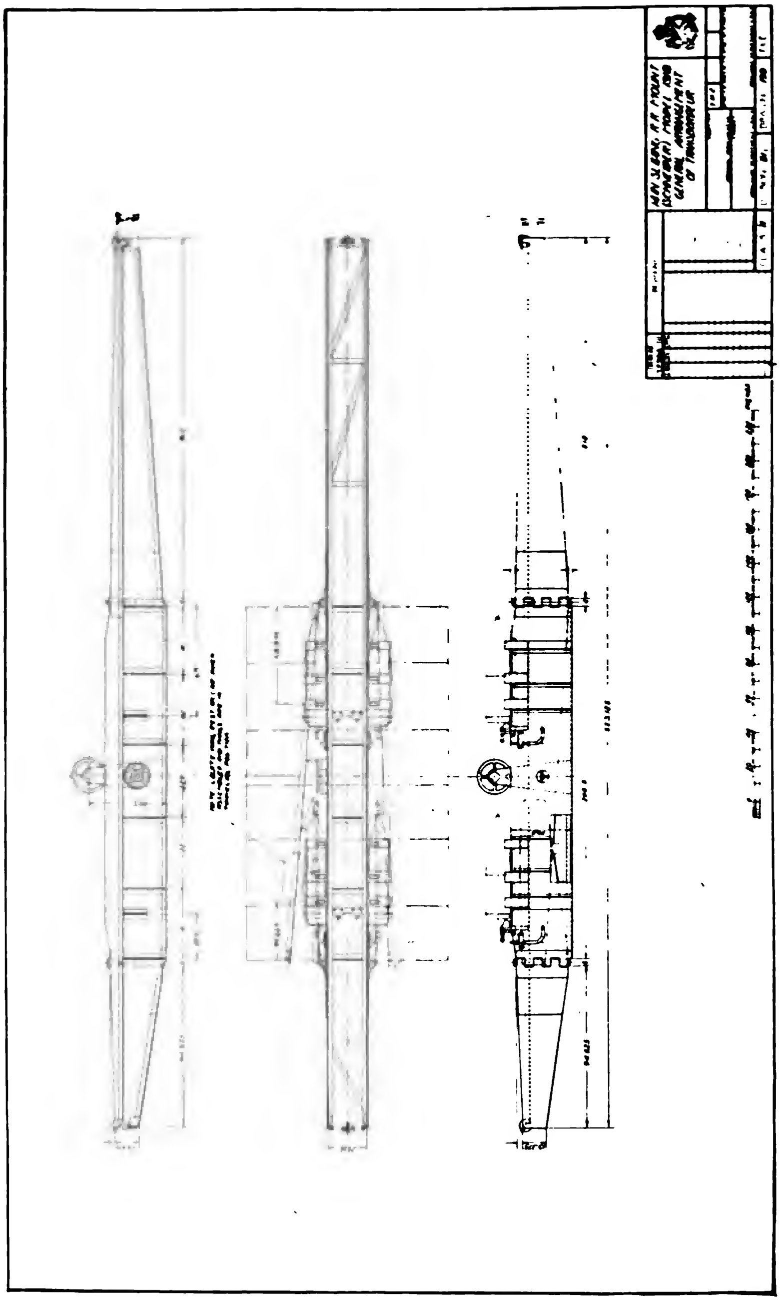

14 IN. SLIDING R.R. MOUNT (SCHNEIDER) MODEL 1918
TRANSBORDEUR
BRAKE ARRANGEMENT
OFFICE OF THE C.O.O. A.E.F.
SECTION A-A
SECTION C-C

PLATE 315



13.—AMERICAN 14-INCH GUN ON SLIDING-TYPE RAILWAY MOUNT, MODEL 1919.(26)

265. This is the alternate design that was made up in France in 1918 for 14-inch, 50-caliber guns. As noted under the description of the model 1918 design, this mount was so designed as to contain a maximum of steel castings. The truck frames, span bolsters, sleeper housings, etc., are all steel castings. The decision to attempt to make these very large parts in the form of castings was the result of difficult manufacturing conditions prevailing in America at that time. It was felt that time could be saved and better results secured from the use of steel castings than from similar parts made of structural steel. Circumstances connected with this mount are mentioned in the description of the model 1918 mount. General views are given on plates 317 to 320.

266. GUN.—The gun employed with this mount is the 14-inch naval rifle, Mark V, Modification I, of 50-caliber length. It is identical in all of its details with the gun described under the model 1918 design.

267. RECOIL MECHANISM.—No recoil mechanism, as it is ordinarily understood, is used in this mount. When the gun is fired, the shock of recoil is transmitted by the trunnions directly into the car body and the entire mount slides back on the track, being stopped by the friction between the sleepers in the bottom of the car and the special firing beams laid on the ties.

268. ELEVATING MECHANISM.—The elevating mechanism provides for a movement of the gun from the loading angle, 0 degree to 38 degrees. It consists of a circular rack bolted to the counterweight on the breech end of the gun, plate 321, a pinion meshing with it and two spur gears, a slip-friction device, a wormwheel and worm, and miter gears on a cross-shaft mounting handwheels on each side of the car body. A chain drive extends from the worm shaft to a 7½-horsepower electric motor and a clutch is provided so that the handwheel does not rotate when the motor is being used. When operated by hand, one revolution of the handwheel moves the gun through 20 minutes in elevation. An antifriction device, of the design shown on plate 322, is provided on the trunnions to reduce the effort required in elevating and depressing the gun. This design is the same in principle but differs slightly in its details from that of the model 1918 mount.

269. TRAVERSING MECHANISM.—It is necessary to operate this mount on a curved track to secure a wide range of traverse. It is possible to traverse the car body on span bolsters by a mechanism, the design of which is shown on plates 323 and 324, and the location and general arrangement of which is shown on plates 319 and 320. Through this mechanism it is possible to secure a traverse of 2.5 degrees on each side of the center line. Attention is invited to the differences in the details of design between this mechanism and the

traversing mechanism for the model 1918 mount. Electric-translating mechanisms are mounted on the two outside trucks and each consists of a 25-horsepower motor connected through spur and bevel gears and two sets of reducing gears to a crank shaft on the outer end of the truck. From the crank pins on this shaft-connecting rods extend on each side to three of the five axles, plates 325 to 327.

270. GUN CARRIAGE.—The gun carriage is incorporated with the car body and the two are described together in the next paragraph.

271. CAR BODY.—The car body consists of two structural-steel box girders connected by heavy deck plates and a series of structural and cast steel transoms, plates 328, 329, and 330. One of the essential differences between the design of these girders and the girders of the 1918 model is that provision was made for a maximum of machine riveting. The 1918 model follows more nearly the French design and requires considerable hand riveting. Another apparent difference is in the scheme of bracing the trunnion bearings. The trunnion bearings on this mount are braced at the rear by extensions of the web plates passing through slots in the top cover plates. Special center-pin castings of large size form the pivots for the span bolsters at either end.

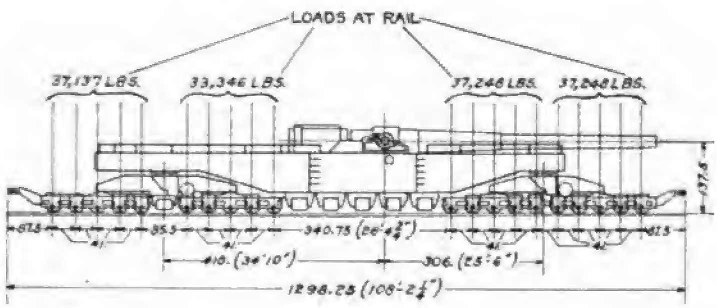
272. ANCHORAGE.—The scheme of anchoring this mount is identical with that described under the previous mount and for the 10-inch and 12-inch mounts as well. Eight lines of 10-inch, 40-pound I-beam bearing stringers are laid on the ties and the weight of the mount rests on these through five sleepers. The sleeper under the rear span bolster receives its main load on the firing of the gun and prevents excessive stressing of the trucks. To facilitate manufacturing of the girders, the sleepers are carried in castings instead of between extensions of the web of the side girders, as is the case with the model 1918 mount. The design of the jack castings, jacks, and sleepers is shown on plates 331 and 332. It will be observed on plate 343 that the rear span bolster sleeper bears directly on the rails through steel shoes and does not rest on the I-beam stringers.

273. TRUCKS.—The trucks are special five-axle locomotive type with 6.5 by 12 inch inside journals, 28-inch cast-steel wheels, and cast-steel side frames and transoms. Hand and air brakes are installed on the exterior trucks, plate 333. The car body is supported on these four trucks by means of cast-steel bolsters of a design shown on plate 334. The traversing mechanism already described is installed in the span bolsters.

274. AMMUNITION SUPPLY SYSTEM.—Ammunition is supplied from the ammunition car to the mount by a shuttle car or transbordeur identical in design with that described for the model 1918 mount. The same design of jib crane, shell tray, and track are likewise used. This gun loads at 0 degree elevation. It will be remembered that the r [illegible] oads at plus 1 degree 30 minutes elevation.

PLATE 316

14 IN. RAILWAY MOUNT-MODEL 1919
TOTAL WEIGHT 725,000 LBS.



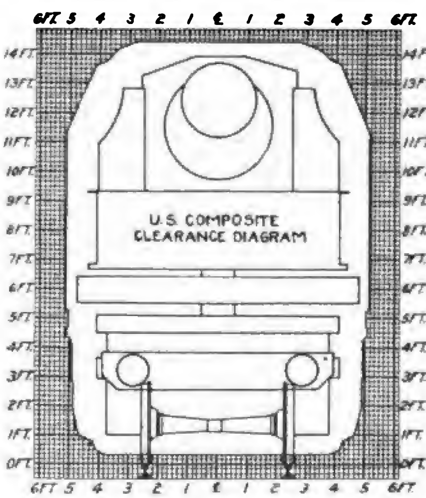


PLATE 317

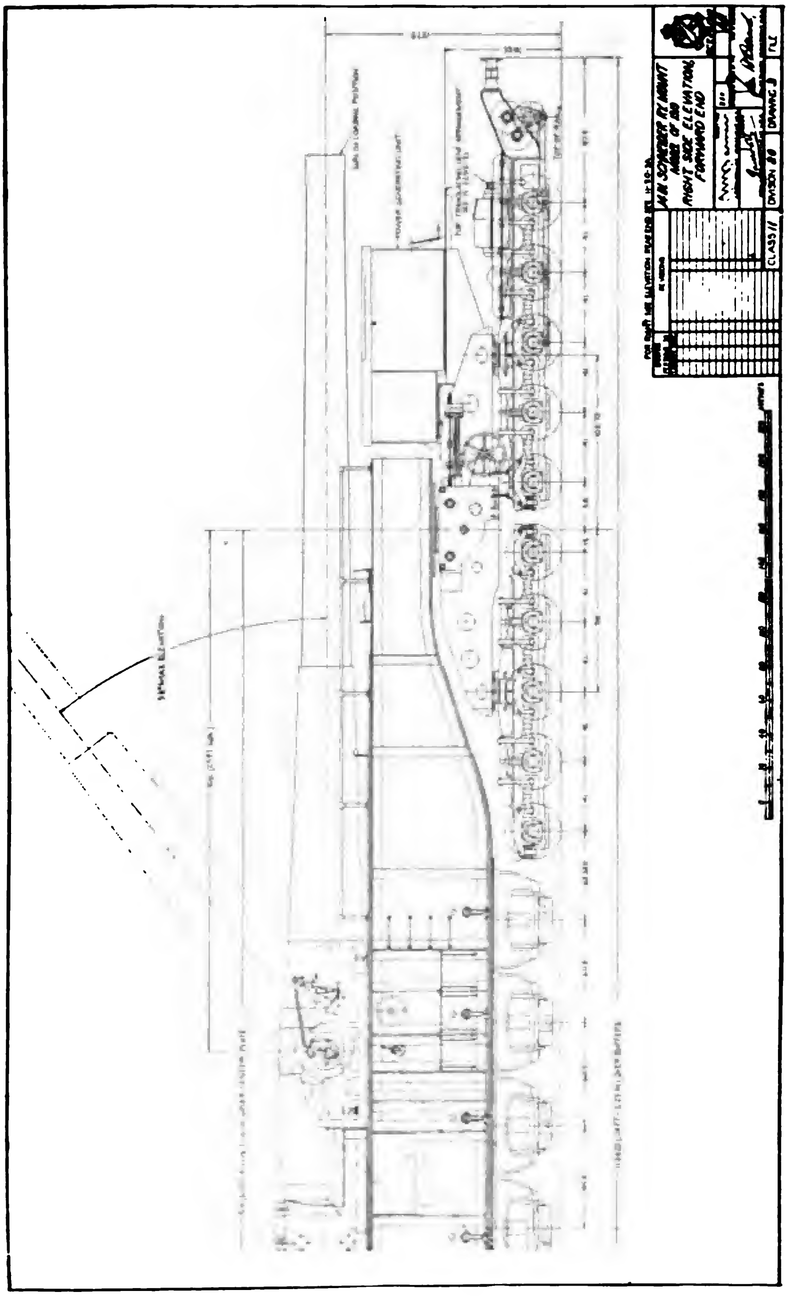


PLATE 318

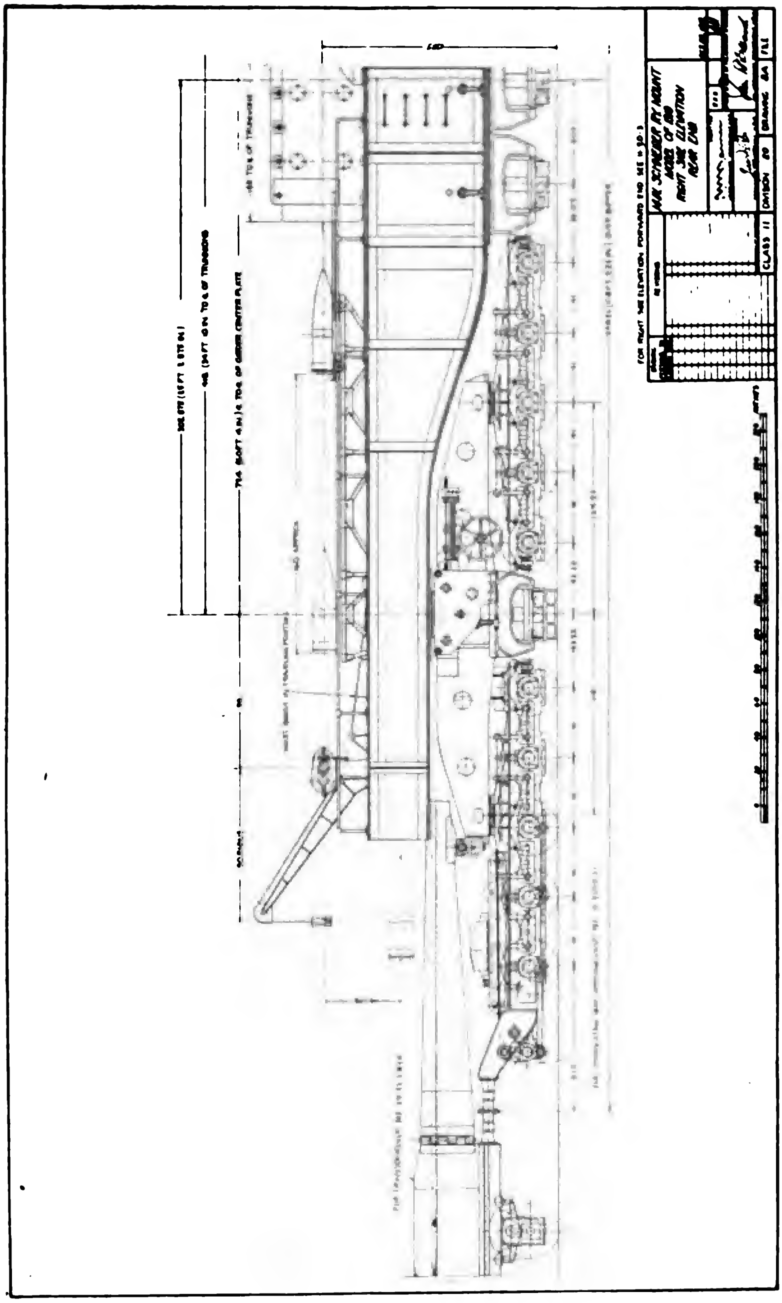


PLATE 319

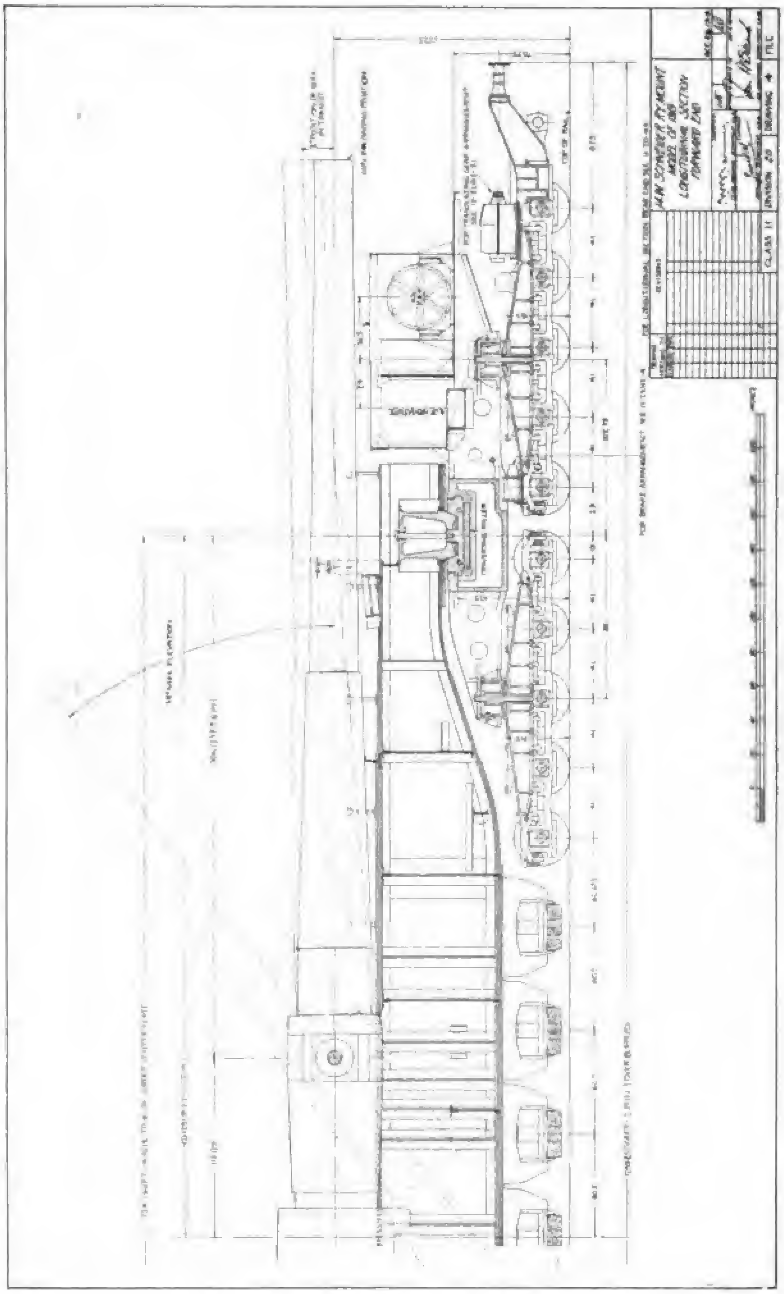


PLATE 320

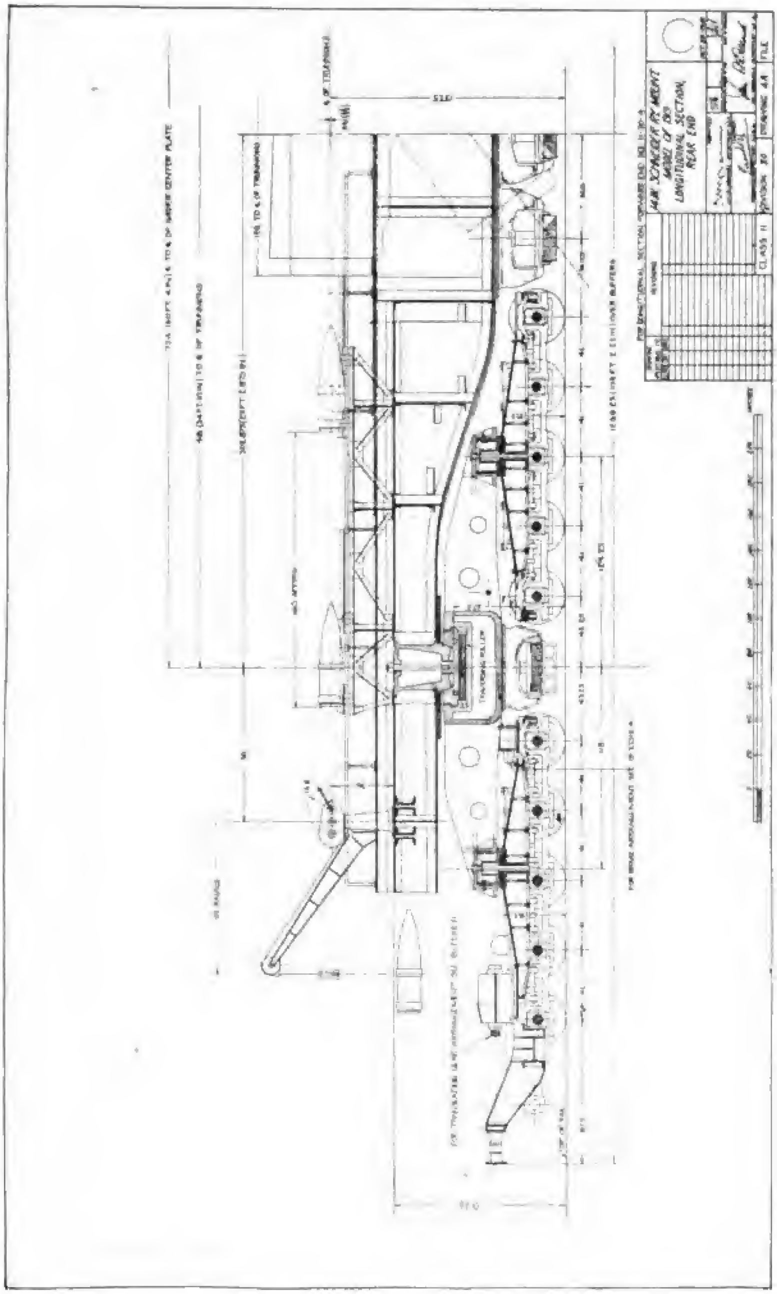


PLATE 321

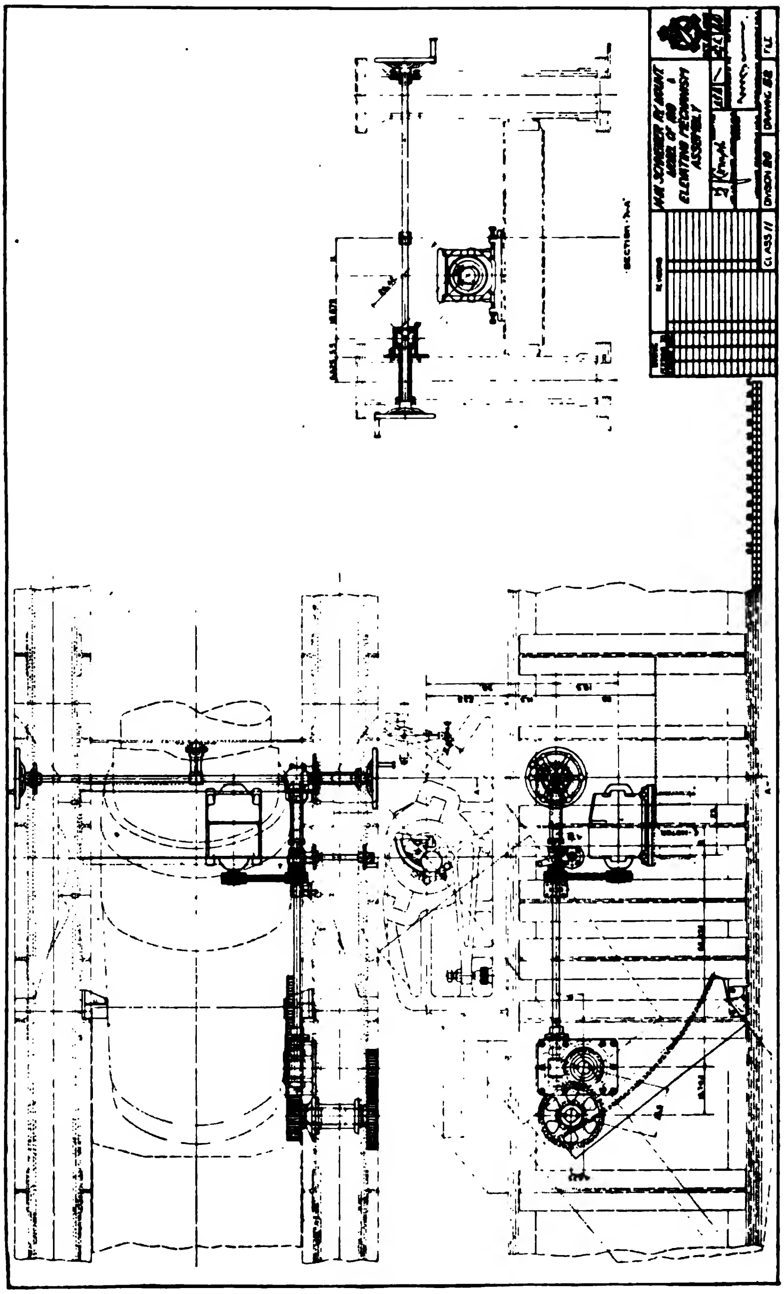
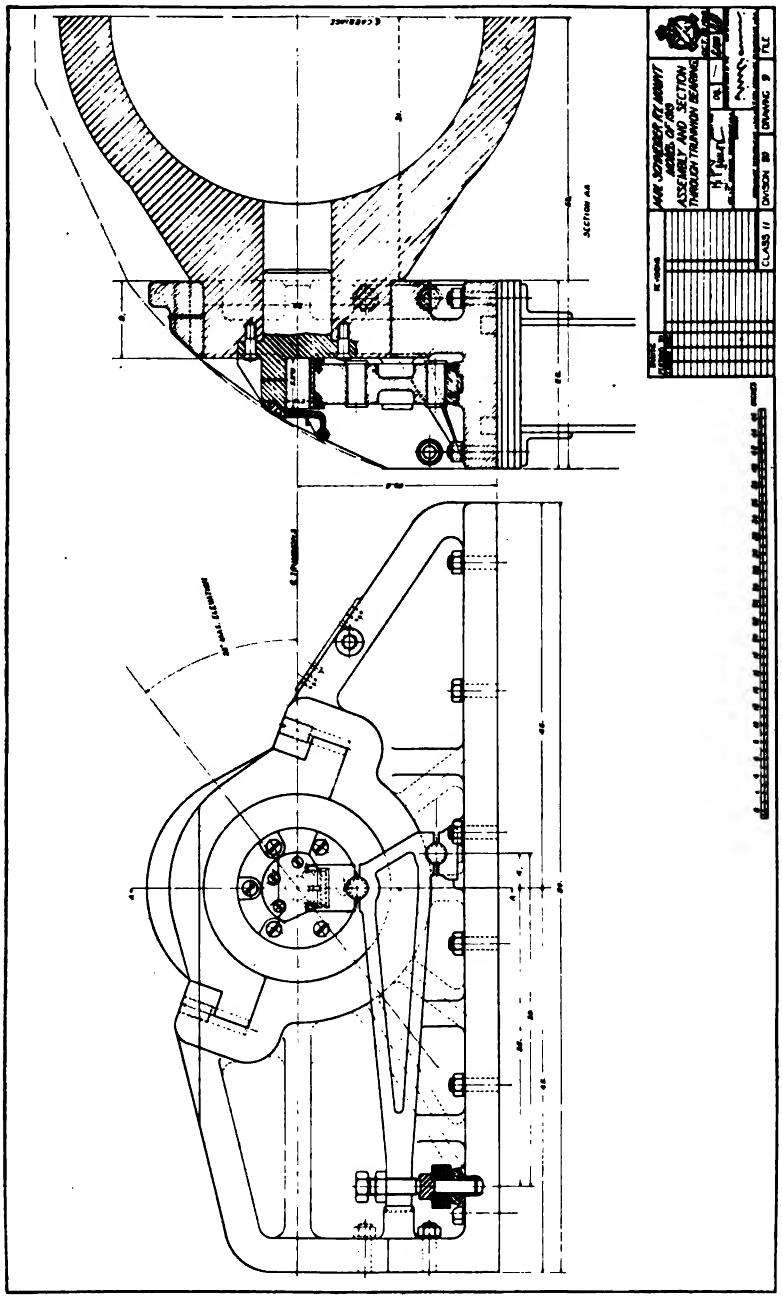


PLATE 322



SCHNEIDER FT. MOUNT
ASSEMBLY AND SECTION
THROUGH TRUNNION BEARING
CLASS II
DIVISION
DRAWING 9
FILE
SECTION AA

PLATE 323

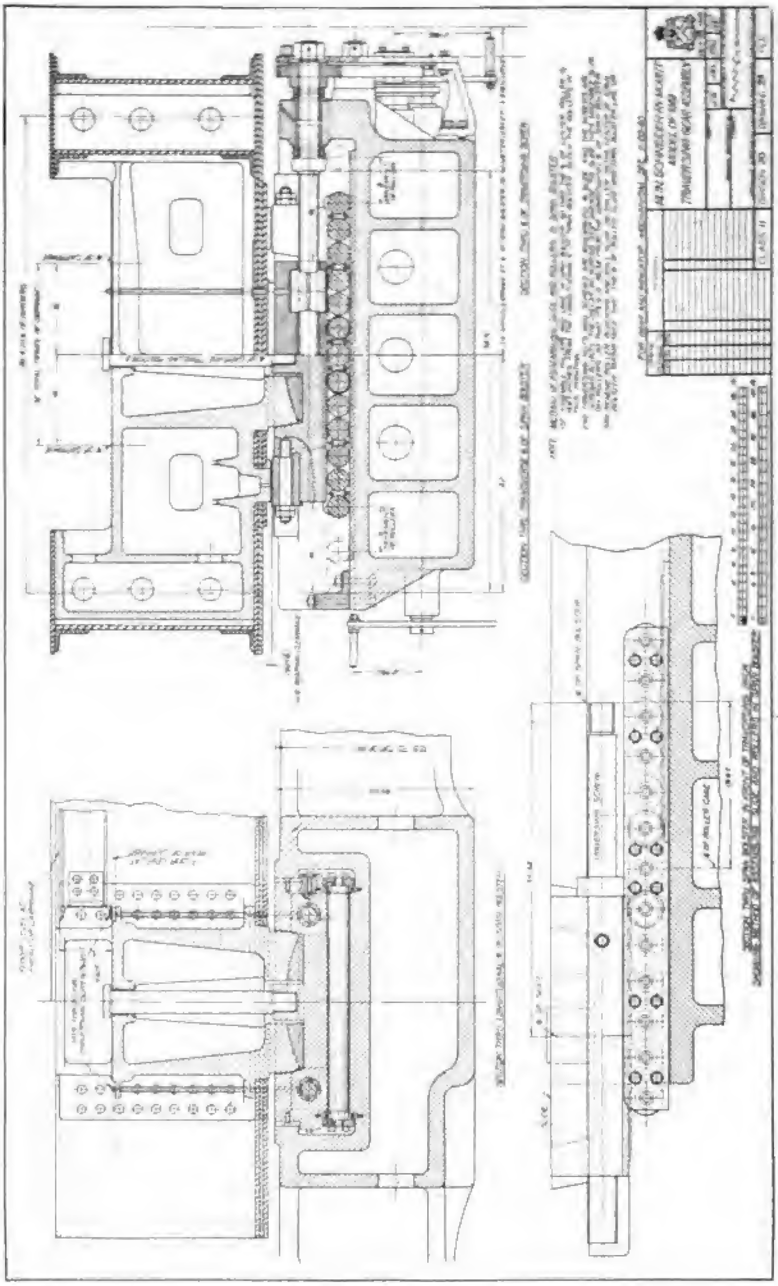


PLATE 324

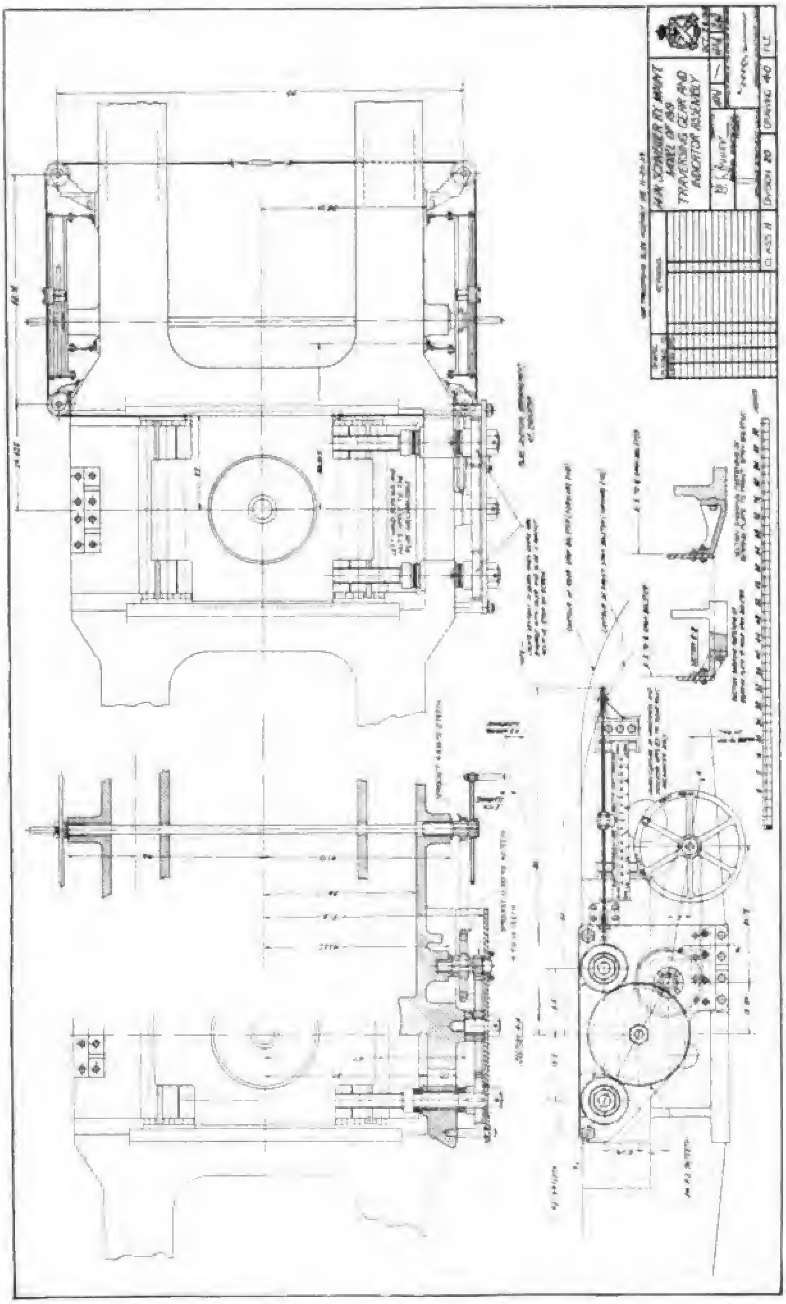


PLATE 325

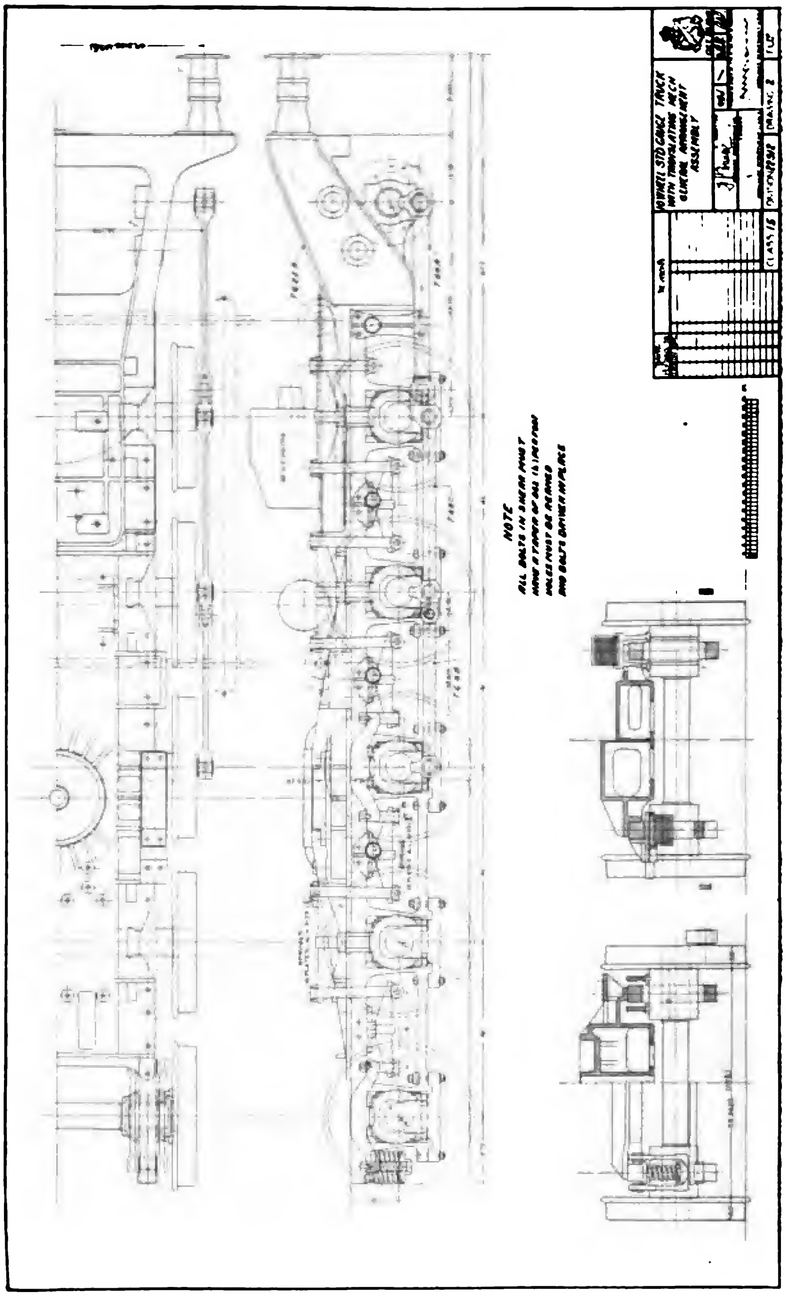


PLATE 326

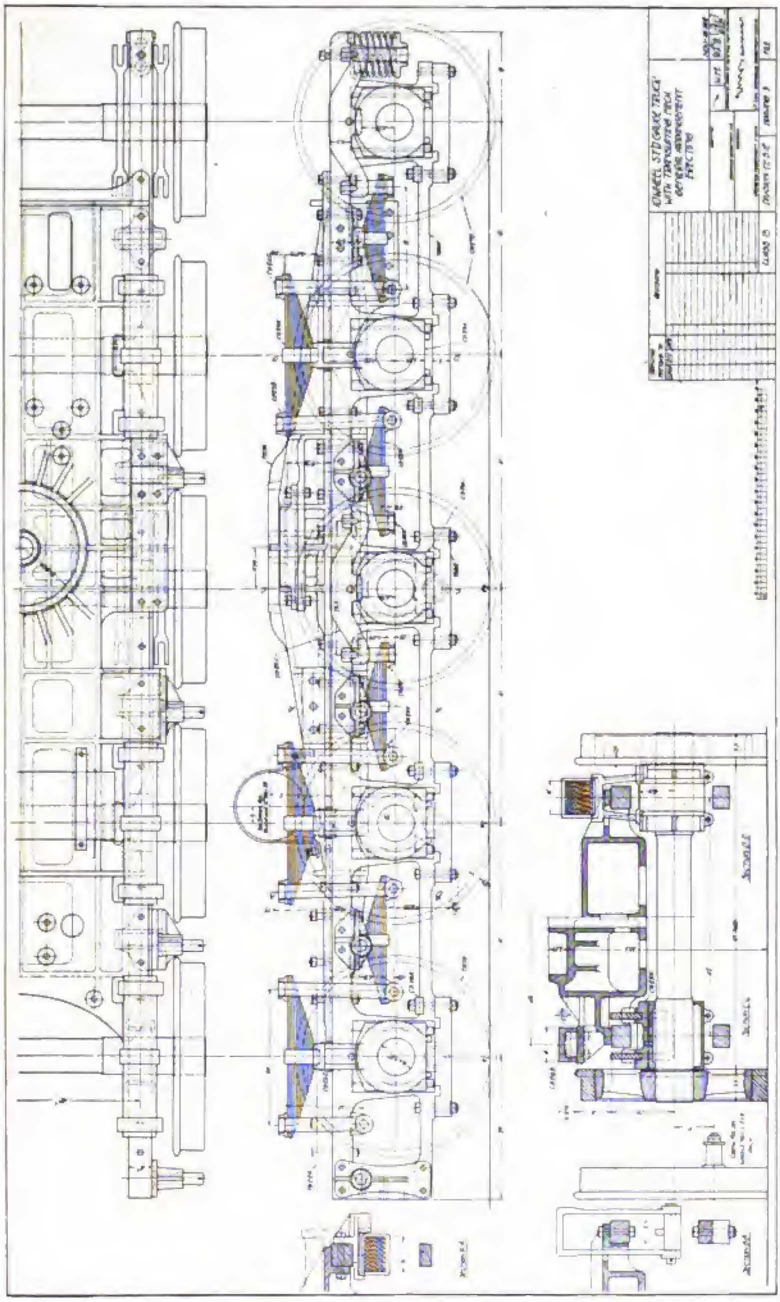


PLATE 327

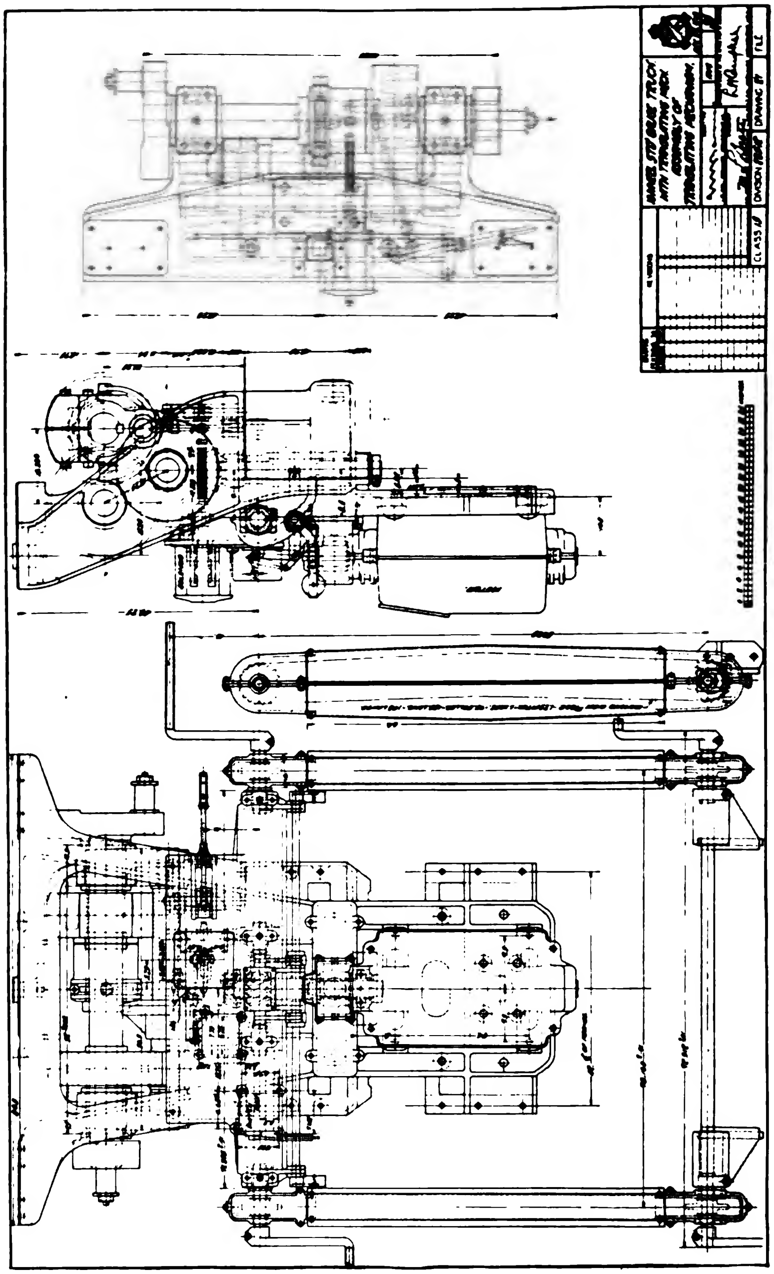


PLATE 328

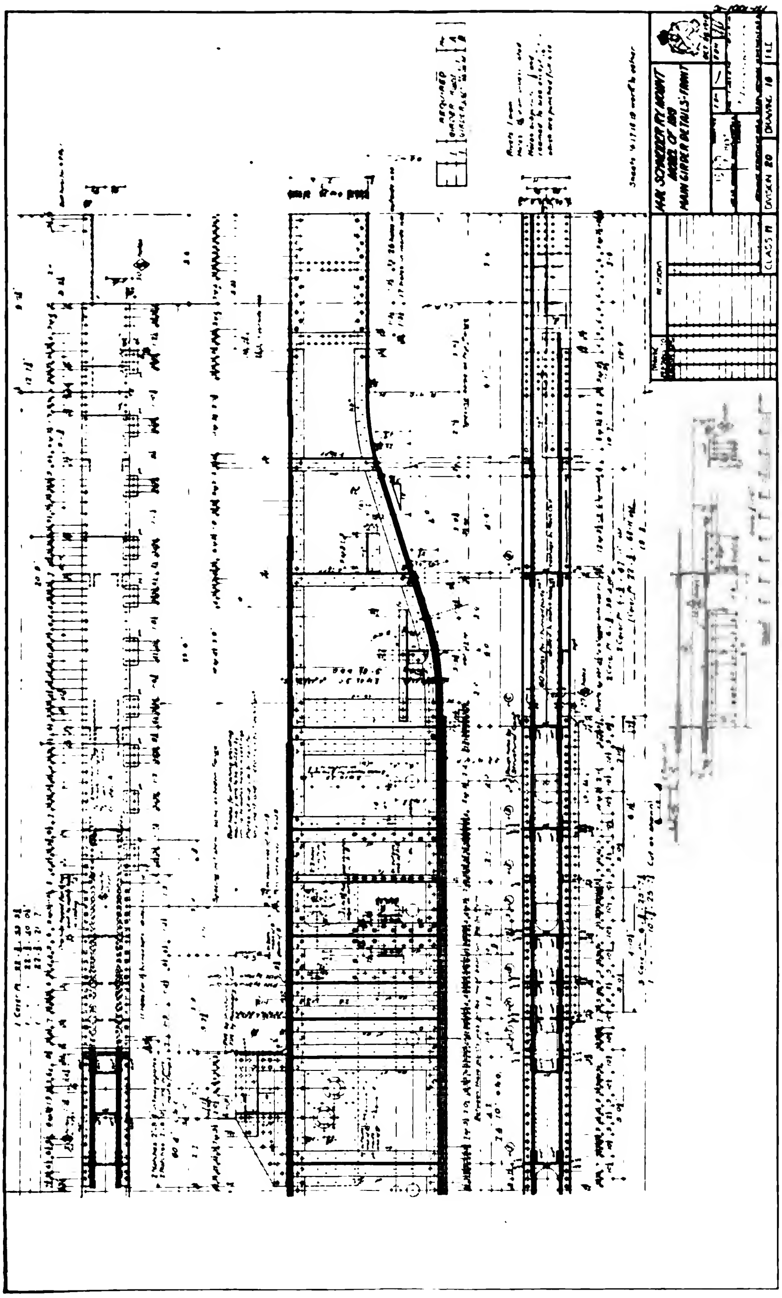


PLATE 329

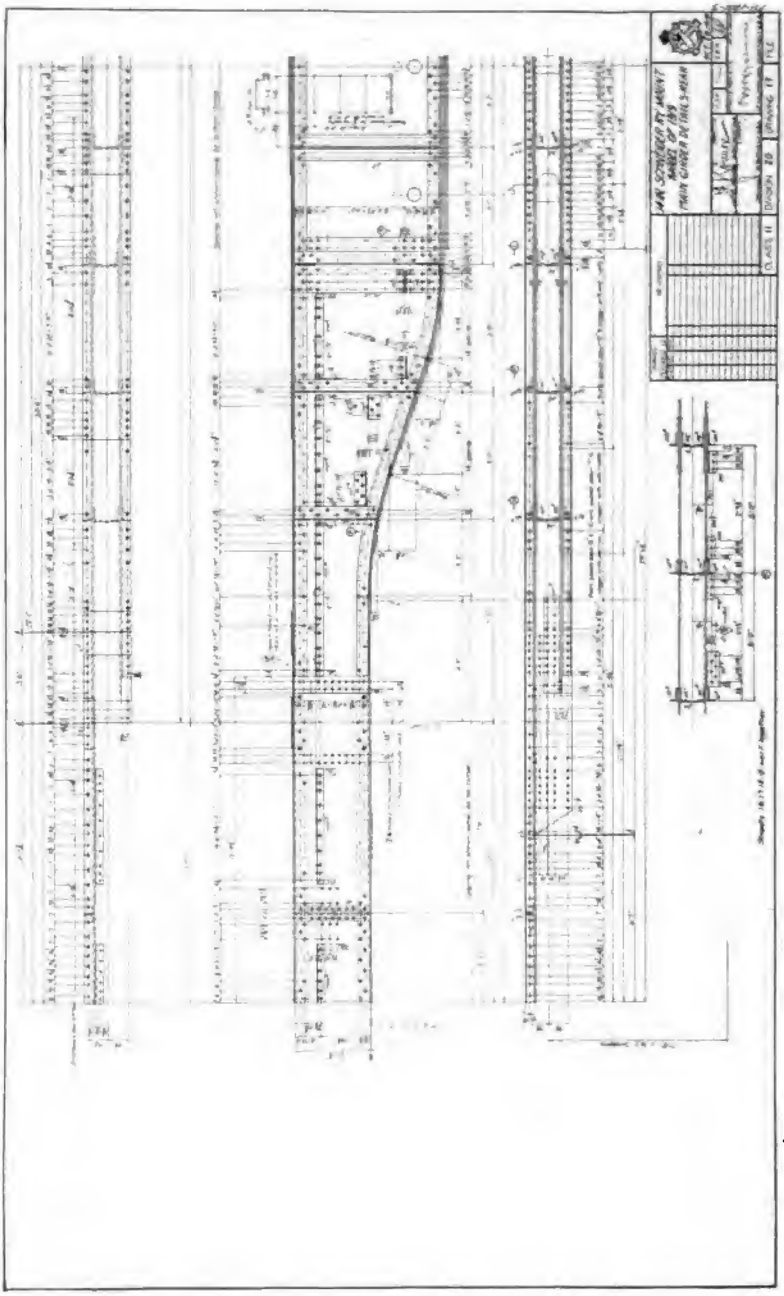
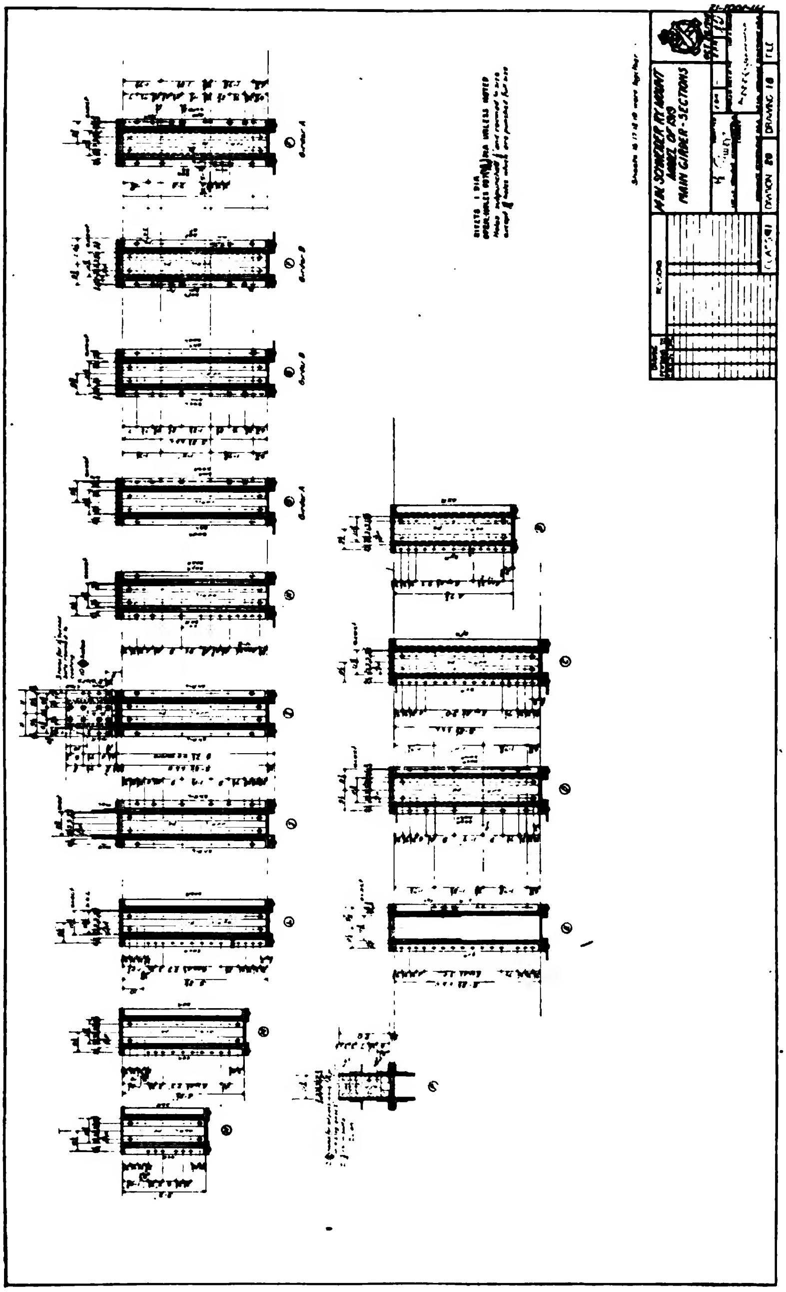


PLATE 330



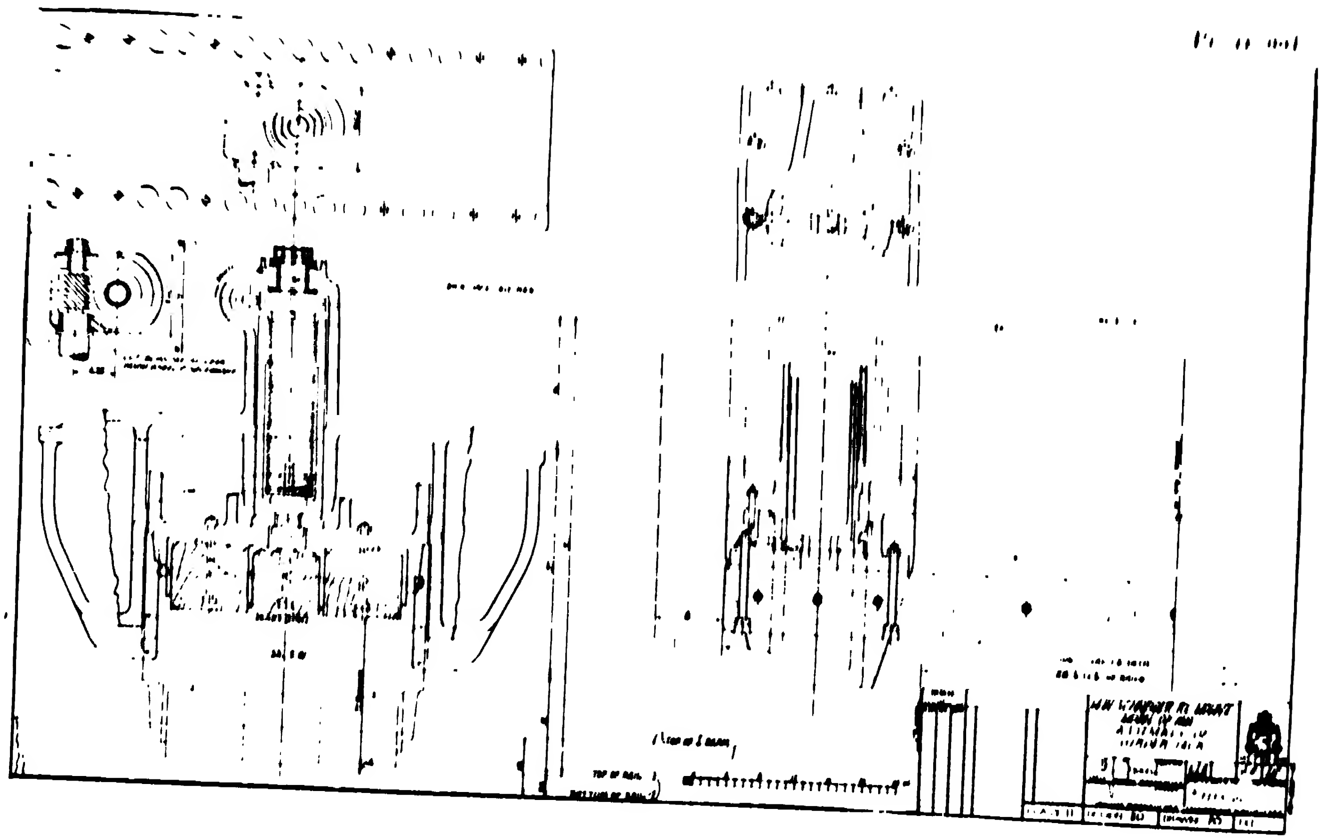


PLATE 332

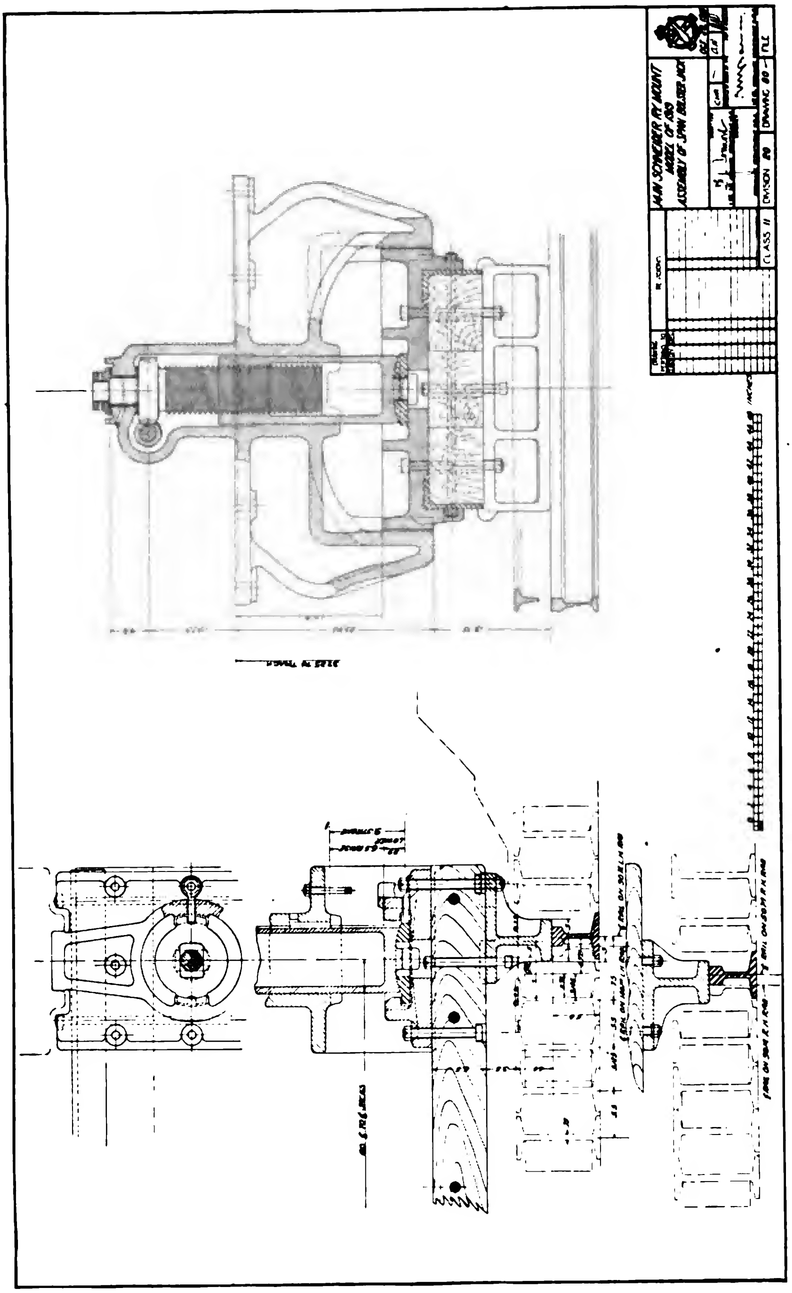


PLATE 333

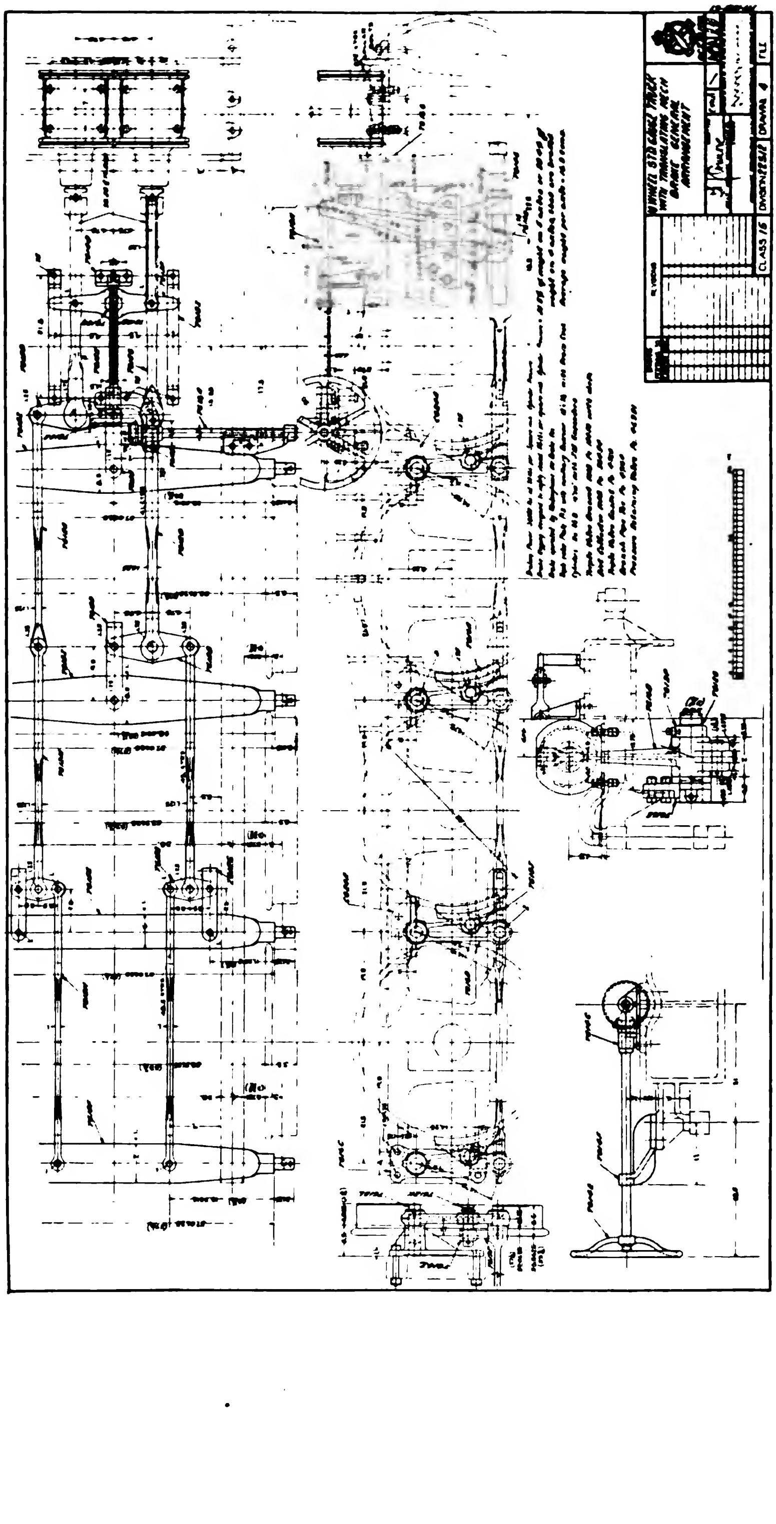
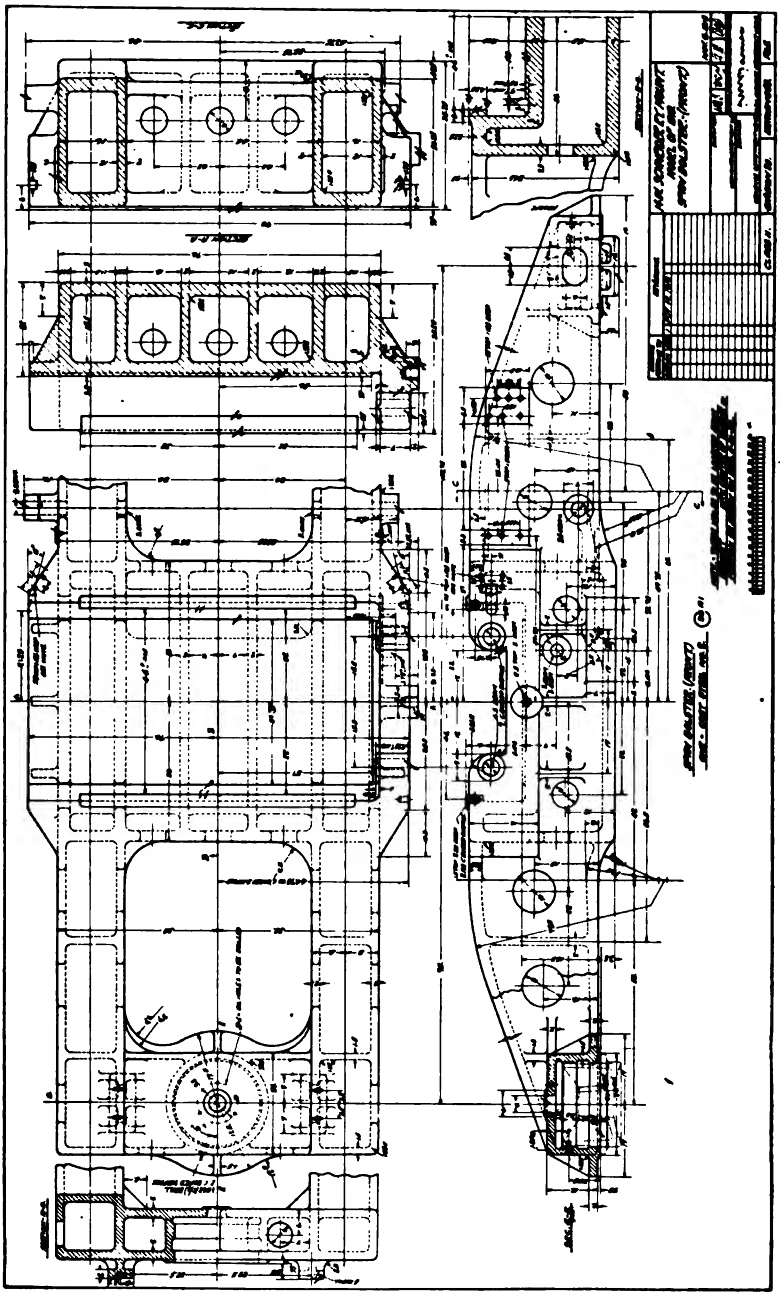


PLATE 334



14.—AMERICAN 16-INCH HOWITZER ON RAILWAY MOUNT, MODEL E. (27)

275. The design of this mount was begun in 1915 at about the time the design for the 4.7-inch howitzer was being completed. In other mounts already described it has been clear that the design has been effected quite largely by French and British development in this type of artillery. The designs for the 4.7-inch gun, the 14-inch gun, model E carriage, and the 16-inch howitzer model E carriage were all designed before American Ordnance engineers had had the opportunity to study any European designs or to learn anything about their developments. It is very gratifying that these designs, especially the 14-inch model E embody features which were considered quite admirable and indicated considerable progress by European designers even at the close of the war.

276. The design of the 16-inch model E carriage was completed in September, 1916, and the work of manufacturing was well underway before America entered the war. A number of characteristics in this design point to a lack of comprehension of the possibility of the railway type of artillery and indicate likewise that the work of design on railway mounts was at the beginning of its development. Apparently it was not realized that it was desirable to avoid the necessity for digging a pit 90 inches deep for the gun to recoil in. The trunnions of the gun cradle, which is the same as the cradle used in the 1918 carriage, might have been mounted at such a height as to reduce the depth of the pit to 2 feet. The other characteristic in mind is the use of so clumsy a device as the radial truck frames for attaching the traversing rollers to the mount. In spite of these obvious defects the carriage stands in point of possibilities for both field and coast service as practically equivalent to the most modern designs in that its emplacement can be installed in a moderate length of time; it can be traversed in any direction from any position, and the howitzer can be operated to a maximum elevation of 65 degrees. General views of the howitzer as it arrived from the arsenal for proving are shown on plates 335 to 339. The general design of the carriage is shown on plates 340, 341, and 342.

277. Gun.—The gun used with this mount is the 16-inch howitzer, model 1918, Mark I, of 18-caliber length. It is carried on the mount in a cradle containing the hydraulic recoil mechanism and spring recuperator system. The gun is fitted with splines which slide in spline ways in the cradle to prevent rotation of the gun. It is rifled with 144 grooves which twist to the right at a pitch increasing from one turn in 40 calibers to one turn in 20 calibers. It is provided with an interrupted thread breech block, which is fitted with a mechanical firing mechanism.

278. Recoil Mechanism.—The recoil mechanism is of the hydro-spring type and comprises two hydraulic recoil cylinders mounted at the top and bottom of the cradle in the center, and four spring recuperator cylinders, mounted two above and two below. The

design of the spring recuperator cylinders, as well as the recoil cylinders, is shown on plate 343. The recoil and recuperator systems of the two carriages, models E and 1918, are identical. On plate 362, a by-pass tube can be seen connecting the front end of the buffer with the rear of the recuperator cylinder. A similar by-pass is provided on the lower cylinder. These by-passes are provided for the purpose of adjusting the length of recoil for various weights of projectiles and powder charges. The maximum length of recoil is 48 inches.

279. ELEVATING MECHANISM.—Elevation is provided from 0 degrees, the loading angle, to plus 65 degrees. The mechanism comprises two segmental circular worm racks attached to the sides of the cradle, Hindley worms, miter gears and bevel gears leading to the cross shaft mounting handwheels on either side of the car. The design of this mechanism is shown on plate 344. To reduce the effort required in elevating and depressing the gun, the trunnions of the cradle are provided with antifriction devices of the rolling wedge or knife-edge type, plate 345. This same design of antifriction device has been used on the 14-inch gun carriage, model E and the two 14-inch naval carriages Marks I and II. One turn of the handwheel moves the gun through 1 degree in elevation.

280. TRAVERSING MECHANISM.—The gun and cradle are fixed with respect to the car body and it is necessary to rotate the entire mount to train the gun in azimuth. The gun and carriage rest by means of 16 rollers carried in radial truck frames, plate 346, on curved railway rails attached to the base ring, plate 341. On either side of the mount, plate 342, identical traversing mechanisms rest on the curved rails of the base ring by means of four rollers and are attached to the mount by means of tie-rods. In each of these a vertical shaft carrying a pinion at its lower end meshing with the traversing rack is driven by two handles through bevel gears. As the mechanism was originally designed, one turn of the crank traversed the gun through 5.75 degrees. This ratio was so high as to make it practically impossible for four men to traverse the mount. The mechanism has been modified and the ratio is now one turn of the handwheel to 0.5 degree in azimuth.

281. GUN CARRIAGE.—The gun carriage is incorporated with the car body and will be described in the next paragraph.

282. CAR BODY.—The gun with its cradle is supported directly by means of the cradle trunnions in cast-steel bearings bolted to the inside of the side girders of the car. The car body is made up of two single web structural steel girders connected, by cast-steel transoms at the ends, and by a cast-steel yoke in the center, plate 347. The cast-steel transoms at the ends serve likewise as body bolsters and carry the body center plate which rests in the center plate of the truck. Examination of the top view, on plate 345, gives one the impression that the girders are not sufficiently braced with transoms and deck plates. It is probable that some weaving of the side girders will be experienced in traveling and consequent difficulty in the operating

of the elevating mechanism, similar to that experienced in the 12-inch, 50-caliber, mount may be the result.

283. ANCHORAGE.—The scheme of emplacing the mount is shown on plates 348, 349, and 341. A conical pit 90 inches deep by 192 inches in diameter at the top and 70 inches in diameter at the bottom must be dug to receive the gun in recoil. A circular trench must likewise be prepared about this pit to receive the base ring. The base ring is cast steel and is made in four parts, plates 350 and 351. This base ring may be carried in four parts in an ordinary flat car or in halves in a special flat car, as shown on plate 348. Seats are machined on top of the base ring for two complete circles of standard 80-pound rails. On the inside of each of the quarter sections are two lugs, the one which serves as an attachment for the lifting beam and the other supports one of the I-beam stringers which carry the service rails used in placing the mount on the emplacement. Timber supports are placed in the conical pit and two I-beam stringers carrying railway rails are placed across the pit, resting on the lugs just mentioned and on the timber support on the center. The traversing rack of each quarter section, plate 350, is cut in order that short sections of rail may be laid across the ring. Small sections of traversing rack are bolted into these openings to complete the rack when the mount has been set in place.

284. Four radial truck frames of a design shown on plate 346, two with inclined top surfaces and two with horizontal top surfaces and each containing four rollers, are placed on the base ring on either side of the mount. Key plates are provided on the inclined surfaces of the lower cords of the side girders forward of the center to receive the forward truck frames. The mount is raised about an inch by means of four hydraulic jacks under the ends of two H beams placed between the car body and the trucks as far forward and back as possible and the trucks removed. The radial trucks are then run under, the mount lowered and bolted to them. Cast-steel transoms connect the radial trucks in pairs and outside clips on the trucks engage with the outside of the traversing rack to prevent overturning of the mount in firing, plate 341. The traversing trucks, which have been placed on the base ring by means of the crane, are now connected to the mount by means of tie-rods. The base ring is placed on well-tamped earth or preferably on a bed of good rock ballast. A minimum of 1½ days is probably required for the preparation of the pit and the placing of the mount ready for firing.

285. TRUCKS.—The trucks are two in number and of standard M. C. B. design. Each has three axles with 6 by 11 inch journals and 28-inch wheels. The trucks are equipped with both hand and air brakes.

286. AMMUNITION SUPPLY SYSTEM.—On the rear of the mount a structural steel frame has been constructed to carry the I-beam track for the ammunition trolley, plates 336 and 340. This I-beam track can be slid to the rear so that it overhangs the track for a considerable

length and the projectile can be picked up either from the track or from a flat car at the rear. No special scheme has been worked out for placing the ammunition at the rear of the mount, but it is assumed that it would be supplied in the standard 8-inch type of ammunition car, plate 106, with special fixtures for 16-inch projectiles, and that it would probably be placed from this ammunition car on a narrow-gauge truck running to the rear of the mount. A special tray has been provided, plate 341, by means of which the projectiles can be carried to the breech of the gun and rammed from it. The powder charge is conveyed to the gun in the same manner.

287. Maintenance.—It is not anticipated that any difficulties would be experienced in the maintenance of this mount. All of its parts are certainly sufficiently sturdy to stand the service for which it was intended. If any difficulty will be experienced it will be in the service rather than in the maintenance of the mount.

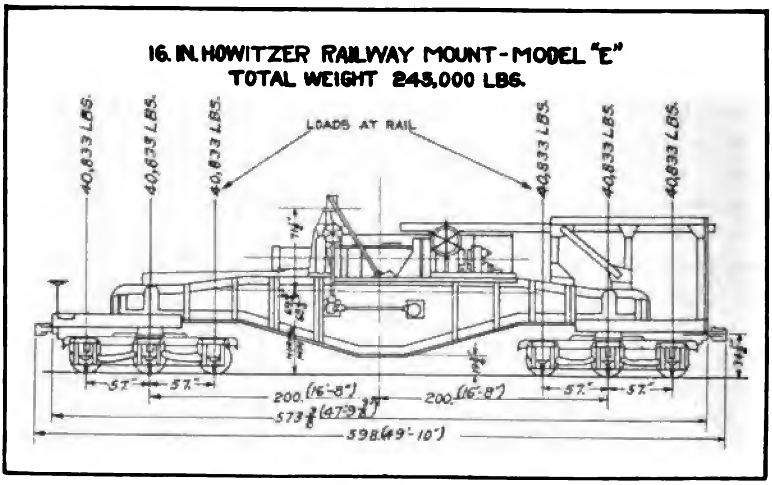
288. Difficulties Involved in Service.—The necessity for preparing so deep a pit to receive the gun in recoil can be classed as a difficulty involved in service of a railway mount. In the event that it is not found possible to operate with the base ring on tamped earth or ballast it becomes necessary to use concrete. This will also be classed as a difficulty in service, because in the European war it was found exceedingly difficult to secure a supply of cement for such uses on the front. It has not been determined whether the noticeable lack of bracing between the side girders will result in difficulties in the operation of the elevating mechanism. This is entirely possible, since the construction is somewhat similar to that of the 12-inch, 50-caliber gun mount on which serious difficulties have been experienced with the elevating mechanism.

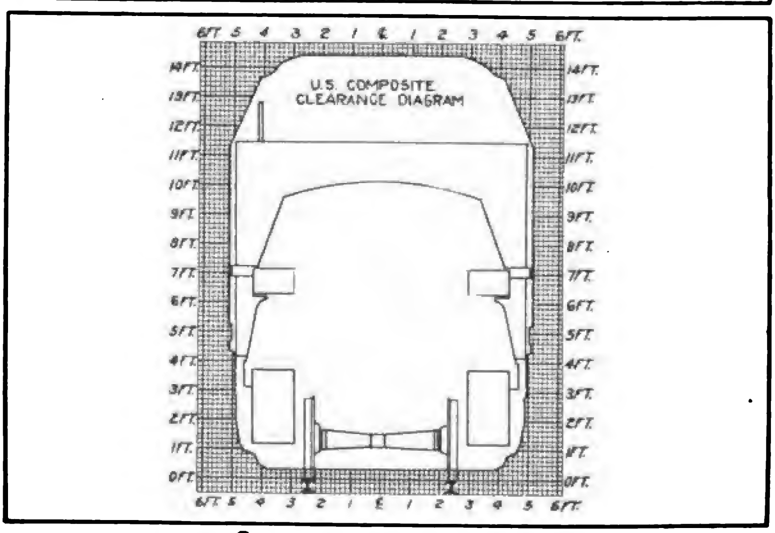
289. Merits.—The possibilities of operating this mount at an elevation as great as 65 degrees and in any direction from any position on the emplacement may be classed as merits. It will be remembered that the necessity for constructing a long curved track to secure sufficient traverse of the gun has been classed as a difficulty involved in service. Such an emplacement as this can be concealed perfectly while the curved track can not. The ammunition supply system may likewise be considered satisfactory in that it is quite simple in design and operates entirely by hand without any difficulty.

290. Demerits.—The necessity for having a pit as deep as 90 inches, when this might have been avoided, is a demerit. The clumsy traversing mechanism is likewise a demerit. This mechanism involves the use of four extremely heavy radial truck frames which are separate pieces of equipment in transit and require a heavy crane for their installation. The elevating mechanism includes Hindley worms which it is felt will give serious difficulty in field service. This type of mechanism is not efficient in comparison with mechanism composed entirely of spur gears, and when compared with the mechanism used on the alternate 16-inch howitzer carriage,

it is not a commendable design. In the near future the necessity for providing so elaborate a piece of accessory equipment as a 120-ton locomotive crane for the installation of a base ring may be considered a serious demerit, although this is not certain. At present one has the choice of using a timber firing platform giving a limited traverse and installed by a Gantry crane of light construction, a curved firing track which can not be concealed from air photographs and requires at least two days for its installation, or a steel base ring which can be installed in about 12 hours and which requires a locomotive crane of 100-tons capacity or more. Since a locomotive crane will in general be included with the equipment of railway artillery parks the necessity for its use on the front may not be a reasonable criticism.

PLATE 335



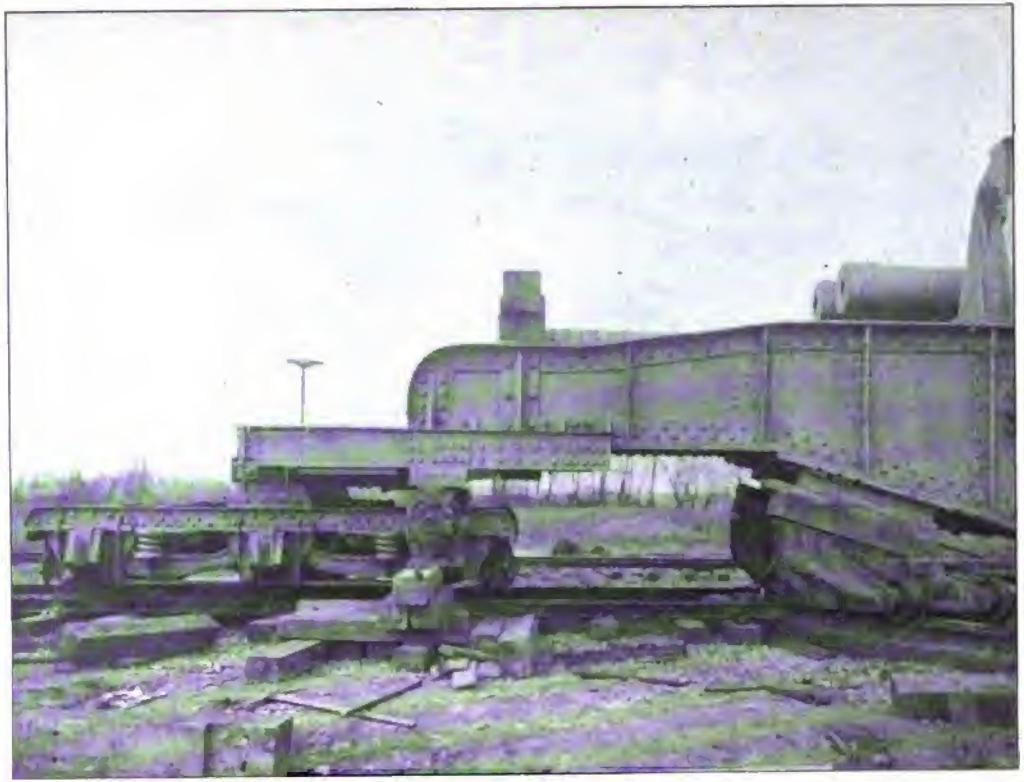


16-INCH AMERICAN HOWITZER MOUNT, MODEL "E."

PLATE 337

16-INCH AMERICAN HOWITZER, MODEL "E."

Plate 338

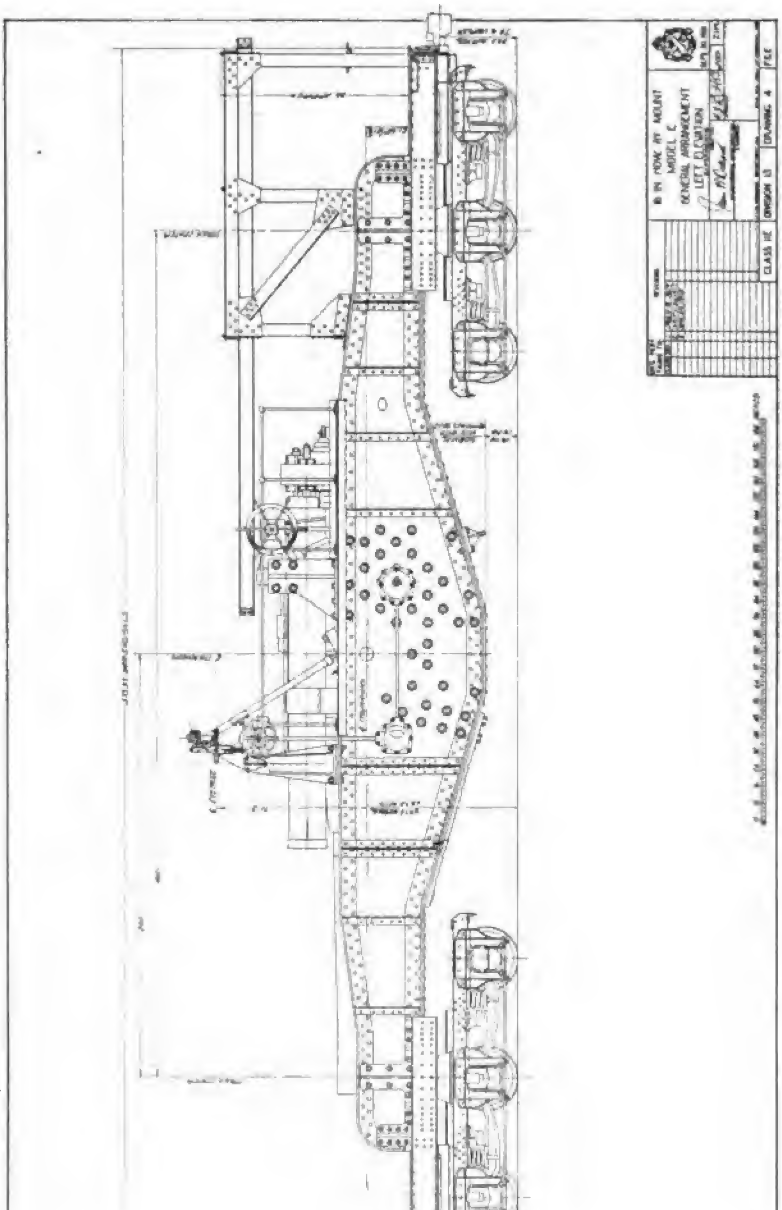


16-INCH AMERICAN HOWITZER, MODEL "E."

Plate 339

16-INCH AMERICAN HOWITZER, MODEL "E."

PLATE 340



181768—21——28

PLATE 341

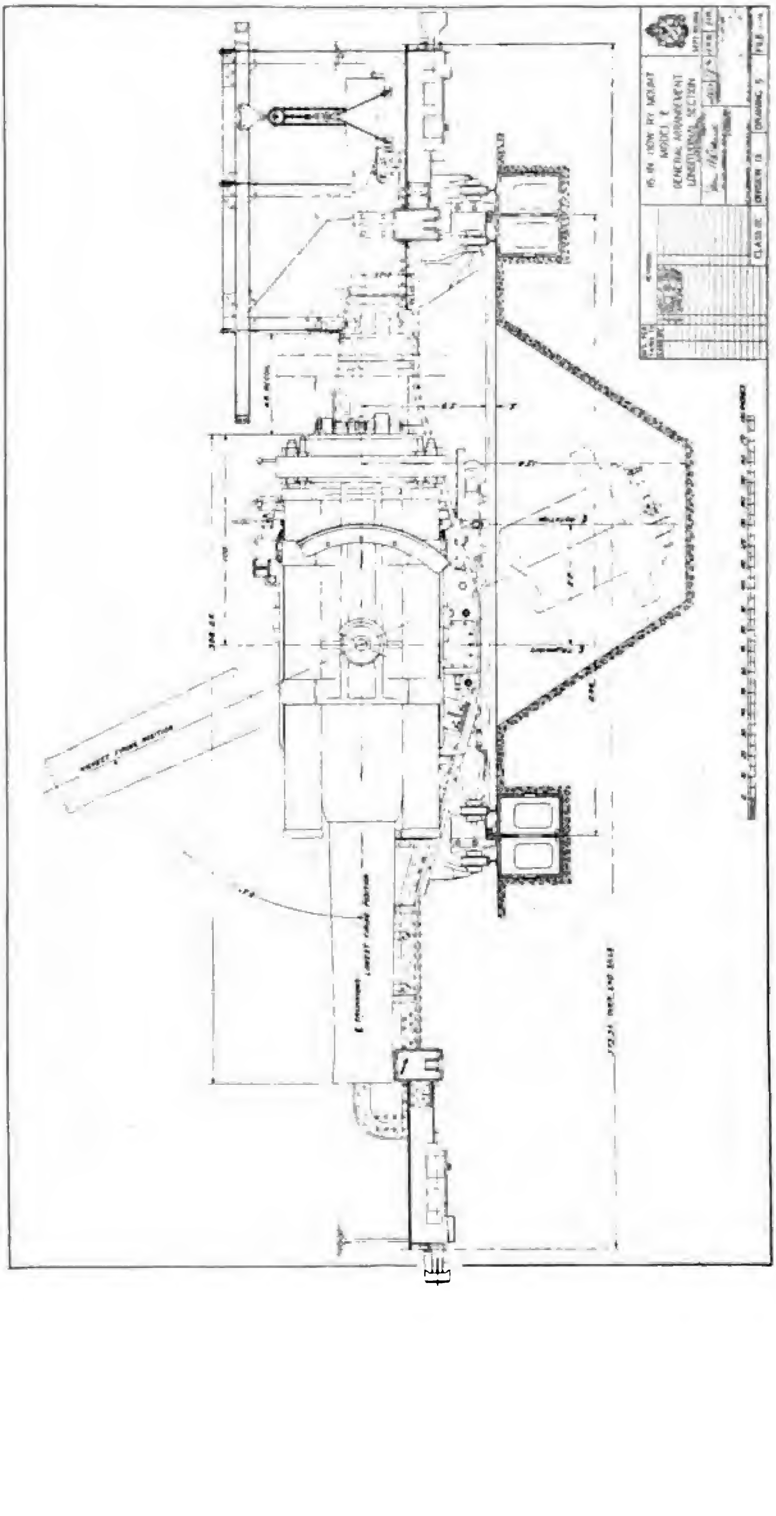

GENERAL ARRANGEMENT
LONGITUDINAL SECTION
CLASS 8E
DIVISION 13
DRAWING 5

PLATE 342

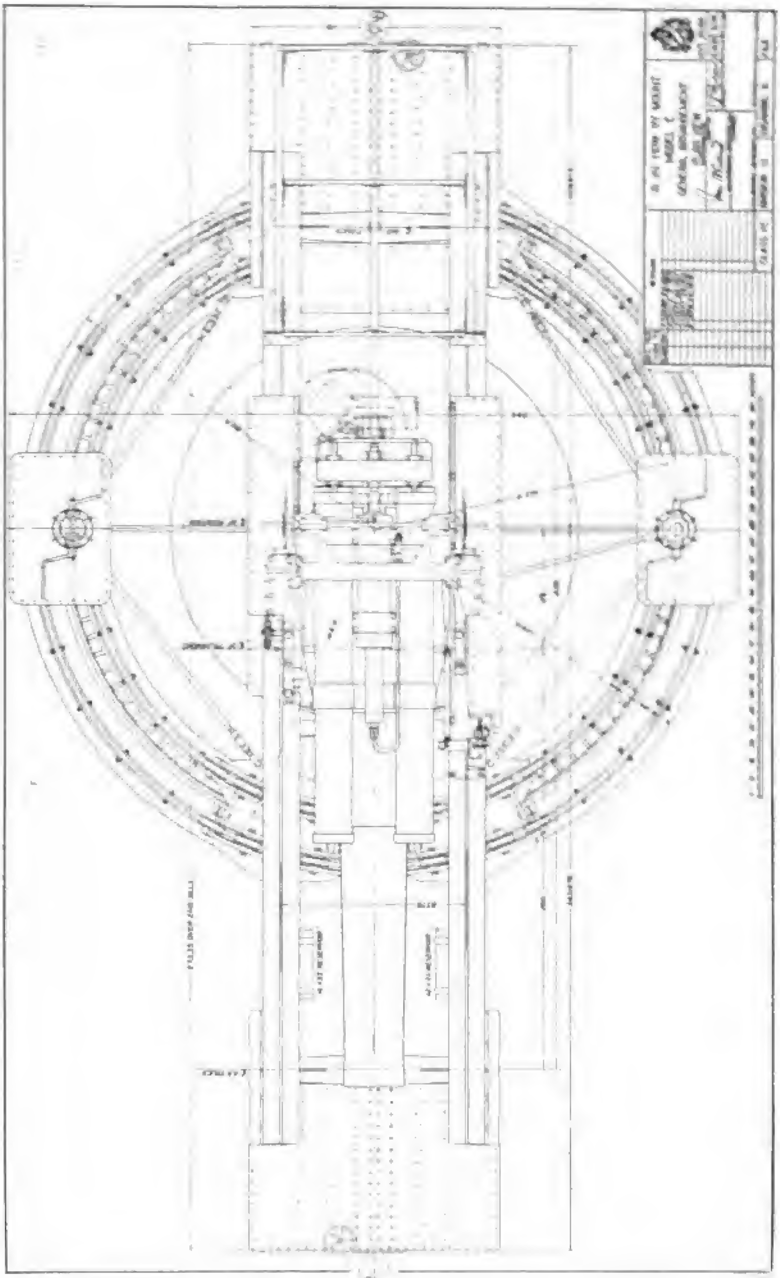


PLATE 343

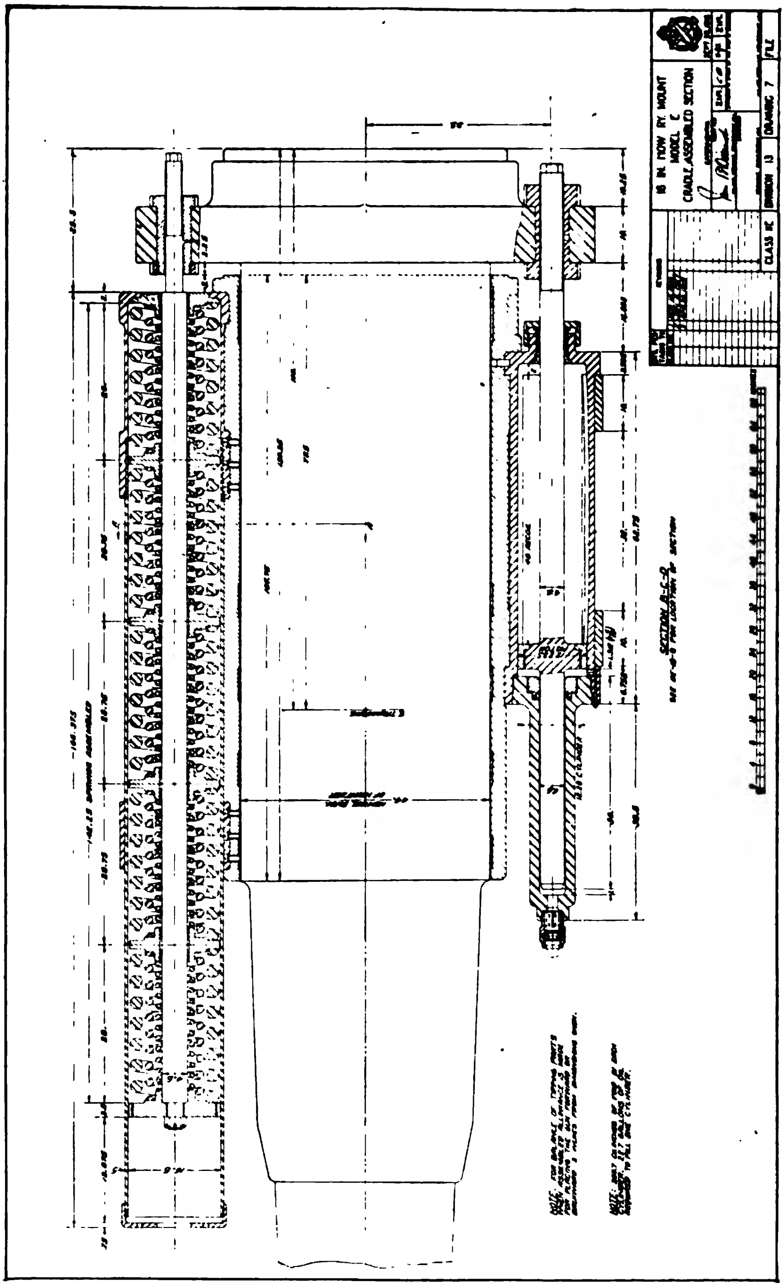

16 IN. HOW RY. MOUNT
MODEL E
CRADLE ASSEMBLED SECTION
CLASS XE
DIVISION 13
DRAWING 7
FILE

PLATE 344

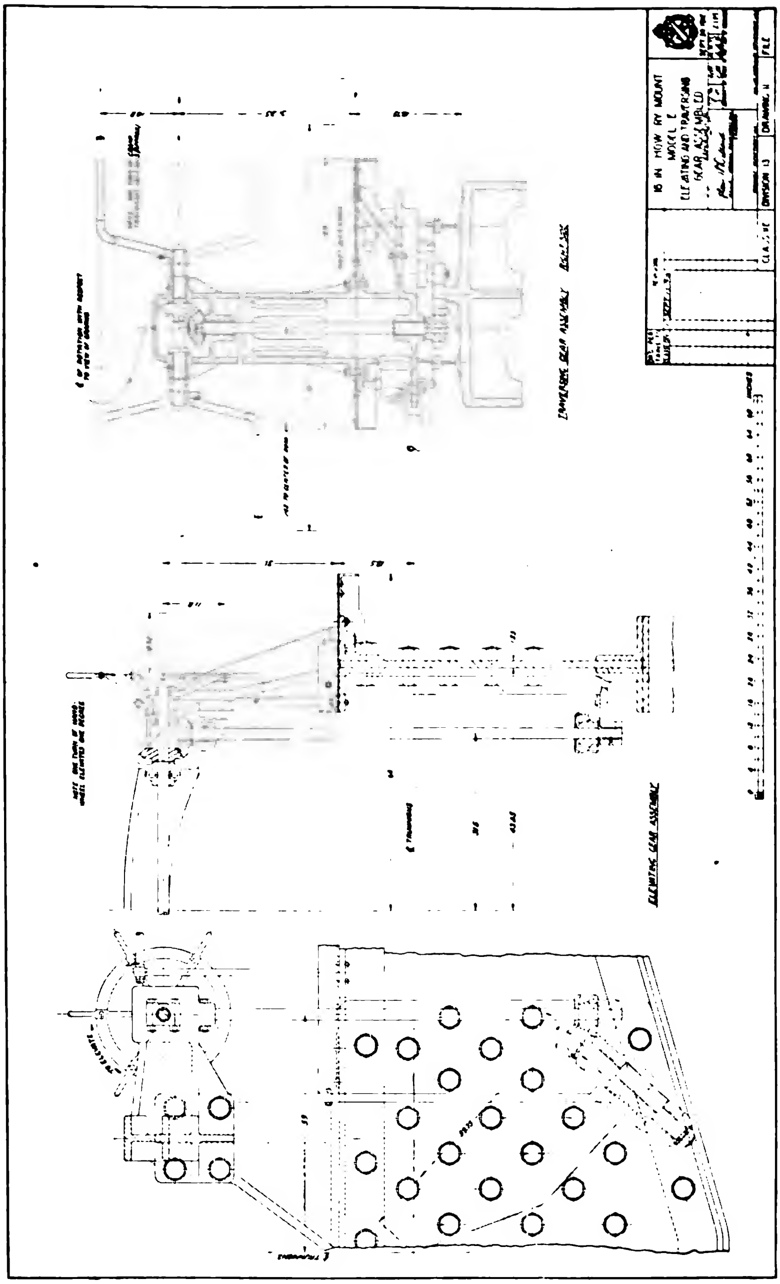


PLATE 345

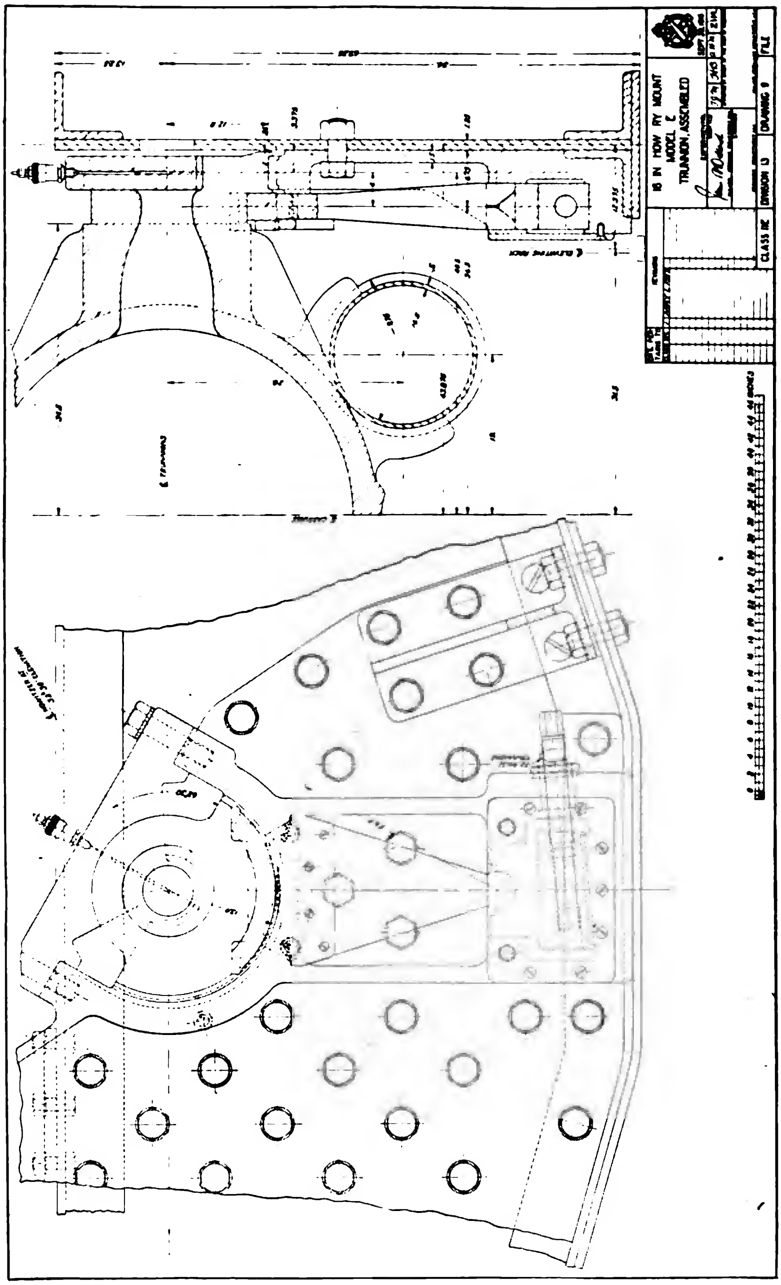

16 IN. HOW. RY MOUNT
MODEL E
TRUNNION, ASSEMBLED
DIVISION 13
DRAWING 9
CLASS 112
FILE

PLATE 346

FRONT RADIAL TRUCK FRAME OF THE 16-INCH AMERICAN HOWITZER MOUNT, MODEL "E."

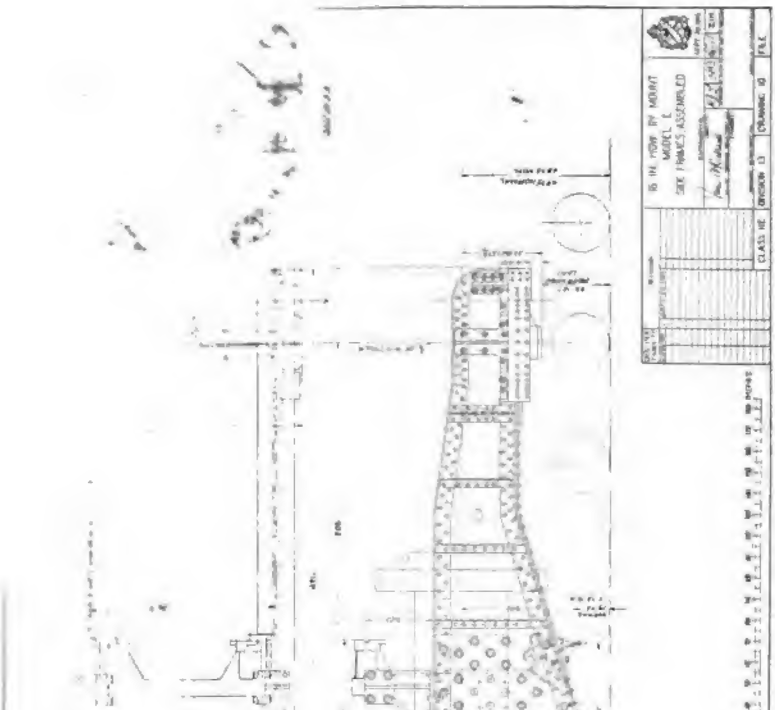

MODEL E
SIDE FRAMES ASSEMBLED
CLASS NE
DIVISION 13
DRAWING 10
FILE

Plate 348

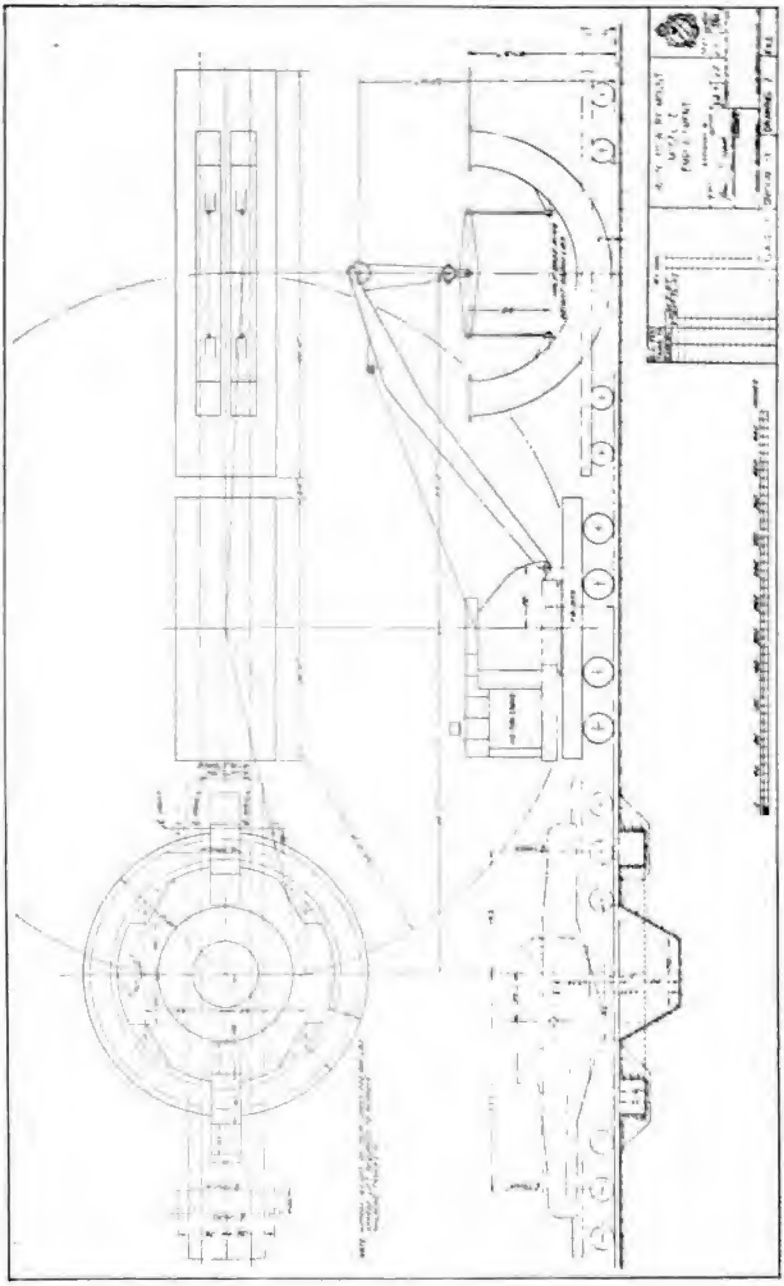


PLATE 347

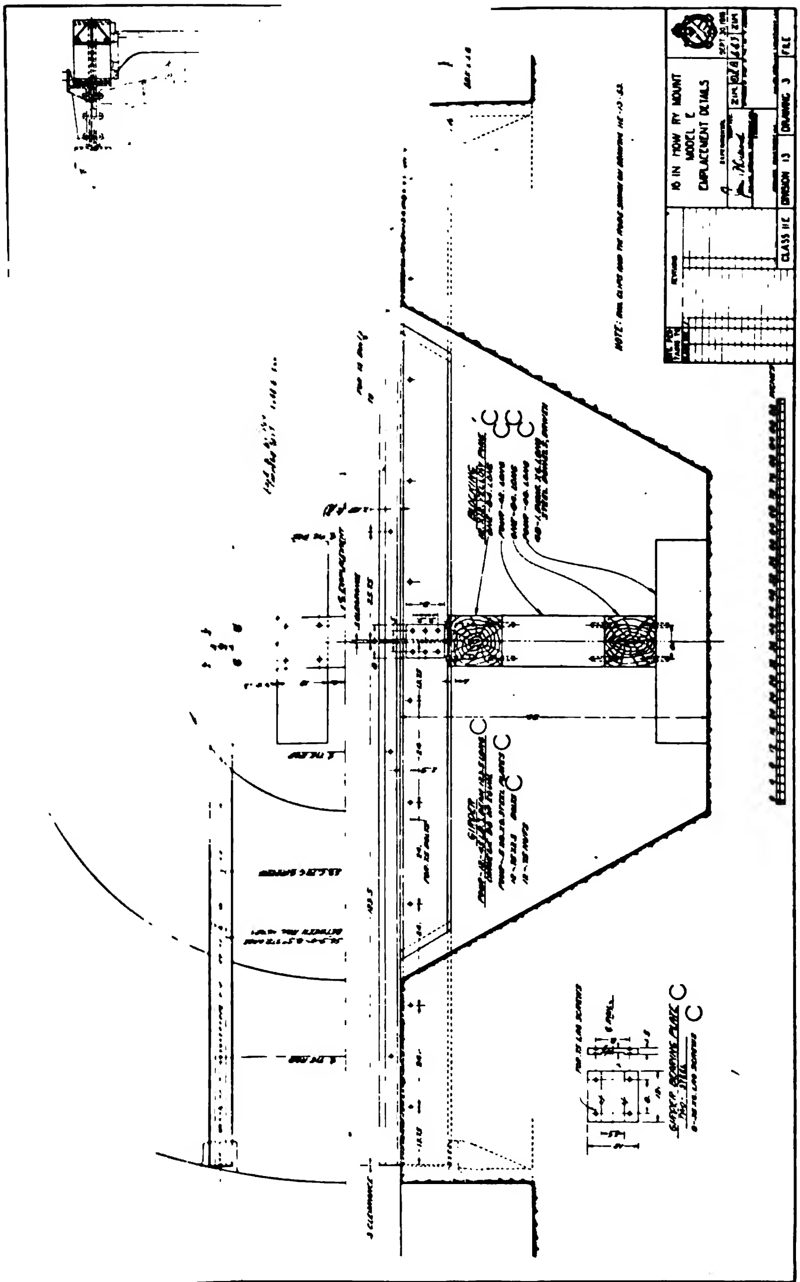

16 IN HOW RY MOUNT
MODEL E
EMPLACEMENT DETAILS
CLASS IIC
DIVISION 13
DRAWING 3
FILE

PLATE 350

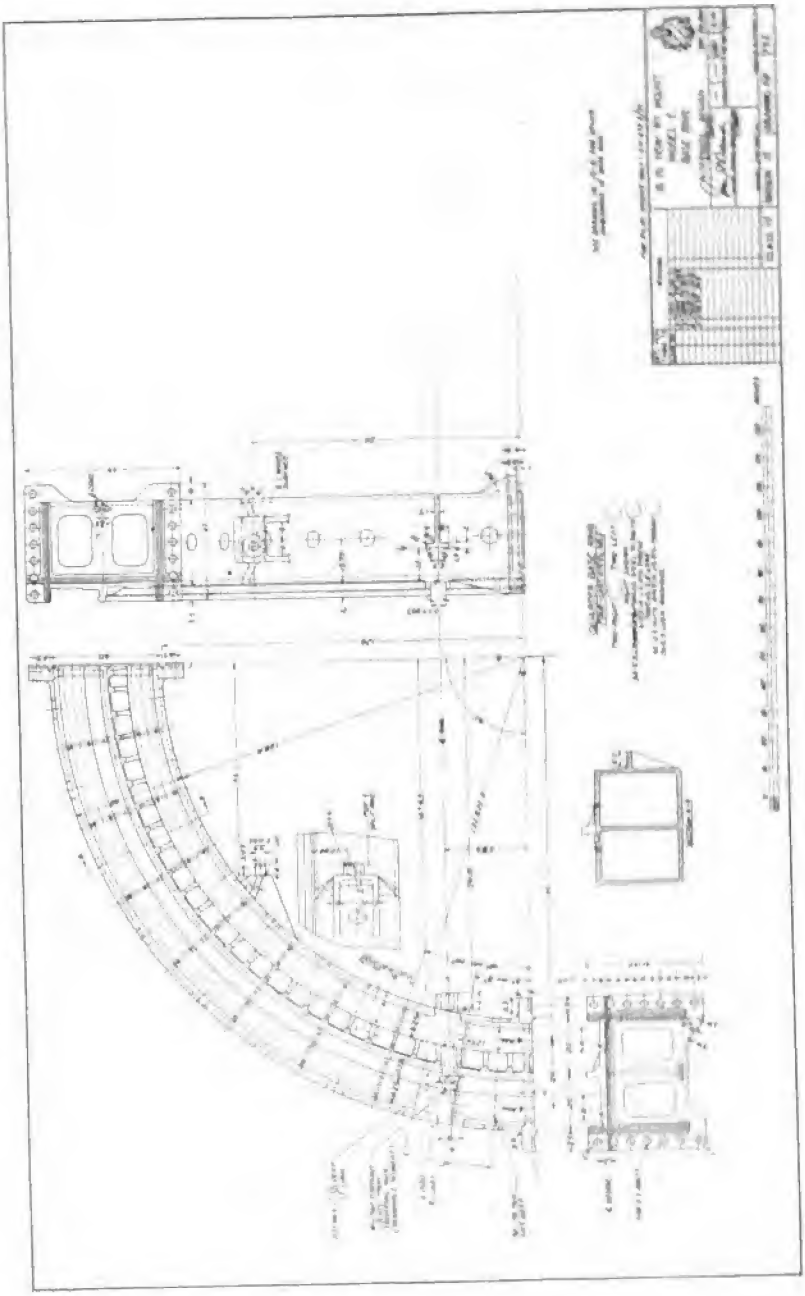


PLATE 351

BASE RING FOR 16-INCH AMERICAN HOWITZER MOUNT MODEL "E."

15.—AMERICAN 16-INCH HOWITZER ON RAILWAY MOUNT, MODEL OF 1918, MARK I. (28)

291. This carriage was designed as an alternate mounting for the 16-inch howitzer, model of 1918, Mark I. The howitzer was originally designed in connection with the 16-inch howitzer carriage, "model E," already described. This mount is of the cradle recoil mechanism type, model 1918, or combined cradle and rolling recoil type, model of 1918, Mark I, in each case with limited traverse. The design is, in general, similar to that of the French 400-millimeter howitzer carriage, plate 25, and the design of its emplacement is likewise similar to that of the 400-millimeter howitzer emplacement. Before the carriage was completed the principle of rolling recoil was receiving considerable attention and a number of trials were made with this carriage operating as a rolling recoil carriage. It functioned very satisfactorily, but it was found that it would be necessary to replace the original five-axle trucks with a stronger type of truck having six axles. The mount can now be used either on the emplacement originally designed in connection with it, or it can be operated as a rolling recoil mount. The maximum elevation obtainable on the emplacement is 65 degrees and the maximum elevation when used as a rolling recoil mount is 45 degrees. The top carriage has a traverse of 5 degrees on either side of the center, which is of course the maximum traverse that can be secured when the mount is used on an emplacement. When it is being used as a rolling recoil mount, any desired amount of traverse can be secured by operating it on a curved firing track. General views are given on plates 353 to 361 and 35.

292. GUN.—The gun used with this mount is the 16-inch howitzer, model 1918, Mark I, of 18-caliber length. It is carried on the mount in a cradle which is provided with hydraulic recoil mechanism and spring recuperator system. The gun is fitted with splines which slide in spline ways in the cradle to prevent rotation of the gun. It is rifled with 144 grooves, which twist to the right at a pitch increasing from one turn in 40 calibers to one turn in 20 calibers. It is provided with an interrupted thread breechblock, which is fitted with a mechanical firing mechanism.

293. RECOIL MECHANISM.—The recoil mechanism is of the hydro-spring type and comprises two hydraulic recoil cylinders mounted at the top and bottom of the cradle in the center, and four spring recuperator cylinders mounted two above and two below. The design of the recoil cylinders is shown on plate 35 and the design of the spring recuperator cylinders, as well as the recoil cylinders, on plate 343, of the model E howitzer carriage. The recoil and recuperator systems of the two carriages are identical. On plate 362 a by-pass tube can be seen connecting the front end of the buffer with the rear of

the recoil cylinder. A similar by-pass is provided on the lower cylinder. These by-passes are provided for the purpose of adjusting the length of recoil for various weights of projectiles and powder charges. The maximum length of recoil is 48 inches.

294. Elevating Mechanism.—Elevation is provided from minus 8 degrees, the loading angle, to plus 65 degrees. The mechanism comprises a segmental circular rack attached to one side of the cradle, a pinion, and a train of four spur gears leading to the operating handwheel. A band brake is provided on the handwheel to prevent undue stressing of the elevating mechanism from the reaction of firing. This band brake is substituted for the slip friction device ordinarily incorporated in the worm wheel of a worm-gear transmission. One turn of the handwheel moves the gun through 1.8 degrees in elevation. The effort required to elevate and depress the gun is reduced by anti-friction devices installed on the trunnions and of a design shown on plate 356. This device has proved particularly efficient and makes it possible to operate the elevating mechanism with very small effort. The details of design of the elevating mechanism proper are shown on plate 357. This is the first design completed on which the elevating mechanism is composed entirely of spur gears. It has proved so much more efficient than other mechanisms which include the worm gears that practically all designs made up since this carriage was completed have been provided with similar types of elevating mechanisms.

295. Traversing Mechanism.—The gun can be traversed with respect to the car body 5 degrees on each side of the center through rotation of the top carriage about its pintle, by means of a mechanism whose design is shown on plate 358. The rear of the top carriage rests on the car body by means of two Belleville spring-supported rollers, and the carriage is rotated about its pintle, plate 335, by turning the vertical shaft which carries on its lower end a pinion meshing with the traversing rack. This shaft is operated by a long ratchet handle. The upper end of the vertical shaft can be seen just in front of the ammunition table on plate 256. The upper end is held in a bearing which is attached to the table. One rotation of the lever traverses the carriage 4.14 degrees in azimuth. When the mount is operated as a rolling mount any desired extent of traverse can be secured through the use of a curved firing track. Under such circumstances only fine adjustments in azimuth are made by means of the top carriage traversing mechanism. It is probable that a very great displacement of the track would result from the operation of the mount with the gun at either of its extreme positions. The personnel operating British 12-inch railway mounts having a maximum traverse of 1 degree on each side of the center reported slight difficulty in the displacement of their track when the gun was operated at even the extreme position of 1 degree traverse.

296. Gun Carriage.—The gun carriage, plates 256 and 53, comprises the cradle carrying the recoil mechanism, and the elevating and traversing mechanisms already described, all mounted, or carried on a structure of cast-steel side frames and transoms. The carriage is provided with a heavy pintle at its forward end, which fits into a bearing machined in a cast-steel transom of the car body. The rear of the carriage rests on the car body by means of spring-supported rollers already described under Traversing mechanism. A structural-steel working platform carrying the ammunition table and crane is bolted to the rear of the cast-steel top carriage. Between the cradle trunnions and side frames antifriction devices already described under elevating mechanism are incorporated to reduce the effort required to elevate and depress the gun.

297. Car Body.—The car body, plates 35 and 53, is made up of two single web structural steel side girders connected by structural and cast steel transoms. Toward the forward end a cast steel transom, machined at its center to serve as a bearing for the pintle of the top carriage, is bolted to the side girders. Center plates and side bearings are provided at either end of the car through which it is supported on two trucks. Outrigger struts, jack supports and ties are attached to the lower cord of the side girders for use in anchoring the mount to its emplacement.

298. Anchorage.—When the mount was designed it was intended to operate it on a timber platform of the design shown on plate 53. The platform is in two principal parts. The one comprises a horizontal bed of timbers on which the mount rests through four jack screws and which takes the dead-weight of the car and vertical component of the shock of recoil. The other is composed of two triangular braces resting against a timber pad. These braces are connected with the mount by means of ball end struts hinged to the mount and resting in foot plates on the ends of the braces, plate 359. This part of the platform takes the horizontal component of the shock of recoil. When the gun is being operated above elevations of 45 degrees, it is necessary to have a pit about 2 feet deep between the two heavy horizontal timber beds, into which the gun may recoil. The rails which bridge this pit and on which the mount is run, are carried on I-beam stringers, plate 53. They are removed for firing. The time required for the installation of platforms for similar French 340 millimeter gun and 400 millimeter howitzer carriages, varies between two and five days according to the nature of the ground and weather. When the gun is fired at angles of 45 degrees or less, the mount may be operated on a track of heavy construction without the use of any firing platform. The brakes are set at a pressure to barely permit rolling of the wheels and the entire mount rolls back a distance of from 30 to 40 feet. To secure any large degree of traverse

it must be operated on a curved track. The mount is drawn back to its firing position by means of a winch mounted on the front truck. This winch is connected with the track some distance ahead by means of a cable.

299. TRUCKS.—The trucks, two in number, are five axle (model 1918) and six axle (model 1918, Mark I), locomotive type with inside journals. The body and bolster are made up entirely of structural steel. The journals are 6.5 inches by 12 inches and the wheels 28 inches in diameter. The axles are equalized throughout, thereby distributing the load evenly over the entire truck. Each truck is equipped with both hand and air brakes. French type couplers and buffers were provided during the active period of the war, but have since been replaced by the standard M. C. B. type.

300. AMMUNITION SUPPLY SYSTEM.—The ammunition car used with this mount is identical in design with that employed with the 8-inch railway mounts, plate 106, with special racks of course, to hold the 16-inch projectiles and powder cans. No special provision has yet been worked out for transferring the ammunition from the ammunition car to the mount. A crane is provided on the rear of the mount by means of which the ammunition may be lifted from the ground on either side of the mount, or from a flat car or from the track at the rear of the mount. After being lifted by means of the crane the ammunition is placed on a tipping tray on the top of the loading stand located on the working platform. When the rear of this tray is tipped up, the projectile slides forward with slight assistance along the removable tray into the breech of the gun and seats itself. The loading angle is minus 8 degrees. This loading apparatus is shown on plate 53.

301. MAINTENANCE.—Every mechanism of this mount has functioned very well on proof tests and no serious difficulty in the nature of maintenance is anticipated. There is one possibility of trouble which may be mentioned under this head. When firing with full charges and at 45 degrees elevation from the emplacement a slight lifting of the mount from the bed at the forward end, and a bending of the struts under the vertical braces at the rear, was noted on two occasions. This bending was due to crushing of the wood under the bearing of the strut and to the fact that the strut had a reduced section near the vertical brace. It is probable that the substitution of another strut with large section and strengthening of the wood beam along the top of the triangular braces will eliminate any future trouble of this character.

302. DIFFICULTIES INVOLVED IN THE SERVICE.—The only difficulty involved in the service with a piece of this type that need receive consideration is the time and care required in the preparation of the emplacement. This has already been discussed at some length under

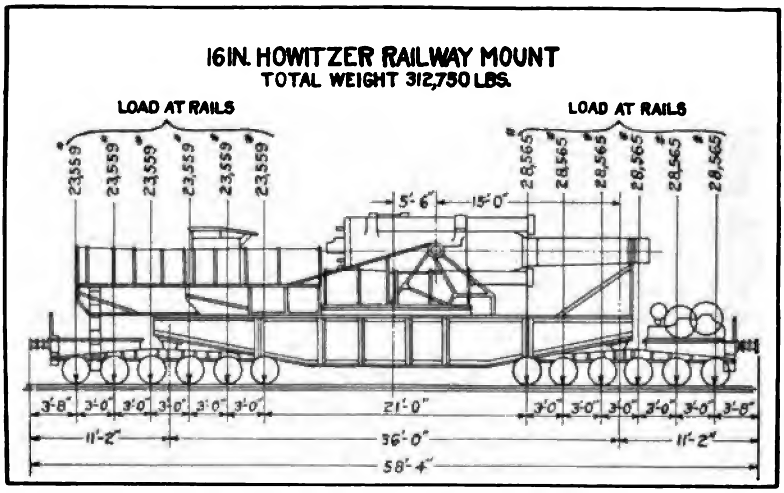
the 14-inch naval mount, Mark I. It is essential either that the emplacement be made in firm soil or that a sufficient bed of cinders, gravel or stone be put under it to insure it against undue settling. It has been mentioned that the mount can be operated as a rolling recoil mount to a maximum elevation of 45 degrees. Since it is probable that for the majority of targets a new track would have to be installed to give the proper direction in azimuth, the difficulty involved in the laying of this track must be considered. Such a firing track must be well constructed and be made up entirely of very heavy components. The firing so far conducted from this mount indicates that a track similar in construction to that employed in heavy commercial service will be satisfactory. The deduction is, then, that the only point in this connection that can be raised is the increase in time required (two days) for placing a special curved track, over that required for another mount carrying a gun of similar caliber, but using an emplacement, possibly of the type employed with the 14-inch model E mount, which can be installed in about 12 hours. No ammunition-handling system has as yet been carefully worked out, but it is not felt that any particular difficulties will be encountered in finding a satisfactory solution.

303. Merits.—This mount has an elevating mechanism of excellent design. As mentioned before, this was the first mount completed on which the elevating mechanism was composed entirely of spur gears. Tests have proved its excellence. The antifriction device has proved equally excellent and the design has been followed on other mounts.

304. Demerits.—The necessity for the use of so cumbersome an emplacement for the operation of the howitzer at high elevation is a serious demerit. What has been said in this respect under the 14-inch naval mount, Mark I, applies equally here. The limiting of the maximum elevation to 45 degrees when the mount is used as a rolling recoil mount is unfortunate. This point is mentioned here, however, only in comparing the mount with the ideal type of mount, for it was originally intended to operate it from the emplacement only; the possibility of operating this particular mount at so great an elevation as 45 degrees without the use of an emplacement is distinctly favorable. It seems certain now that a carriage can be designed on which the gun can be operated to an elevation as great as 65 degrees with the mount operating either as a combined sliding and cradle recoil mount or as a fixed emplacement mount, the emplacement involving no more elaborate components than those employed with the 8-inch gun and 12-inch mortar.

181768—21——29

PLATE 352


16IN. HOWITZER RAILWAY MOUNT
TOTAL WEIGHT 312,750 LBS.
LOAD AT RAILS
LOAD AT RAILS
23,559
28,565
5'-6"
15'-0"
3'-8"
3'-0"
21'-0"
11'-2"
36'-0"
58'-4"

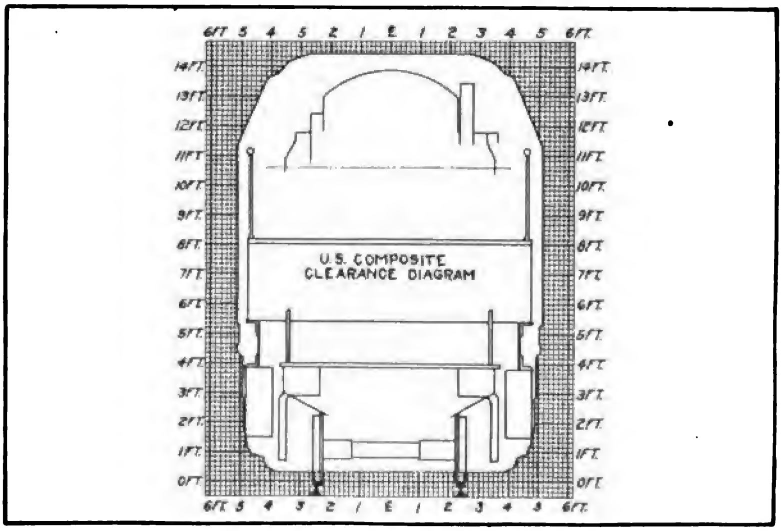
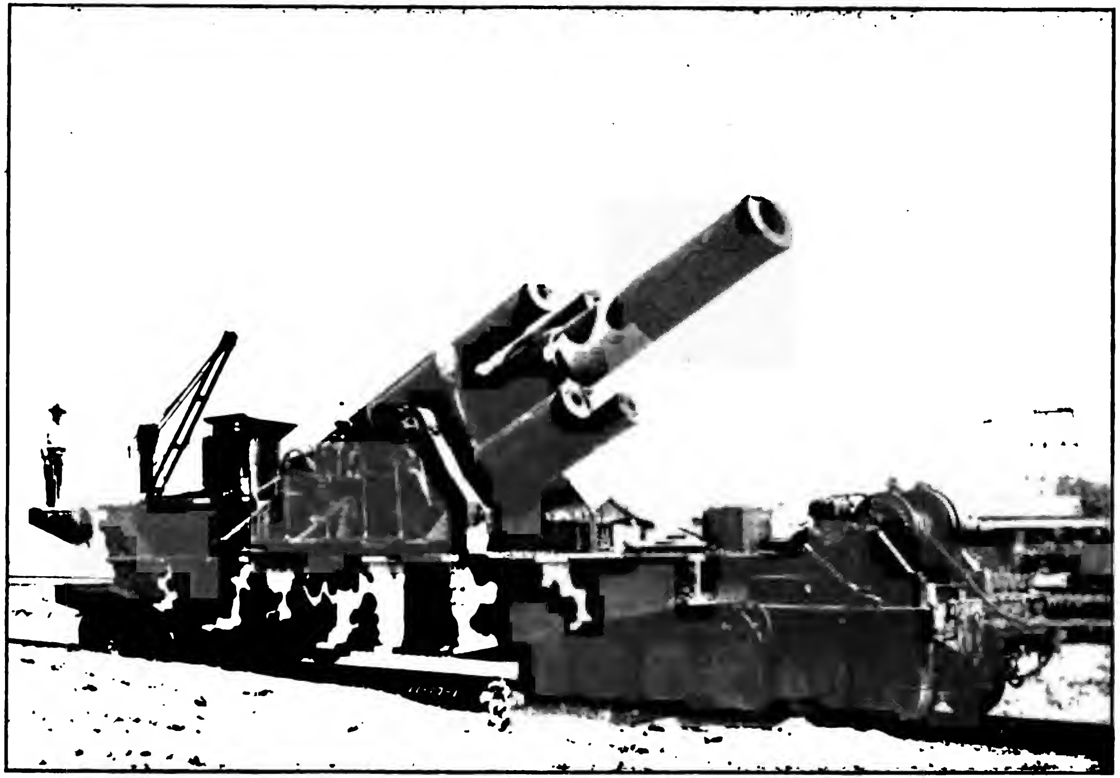

U.S. COMPOSITE
CLEARANCE DIAGRAM

Plate 353



16-INCH AMERICAN HOWITZER MOUNT, MODEL 1918.

Plate 34

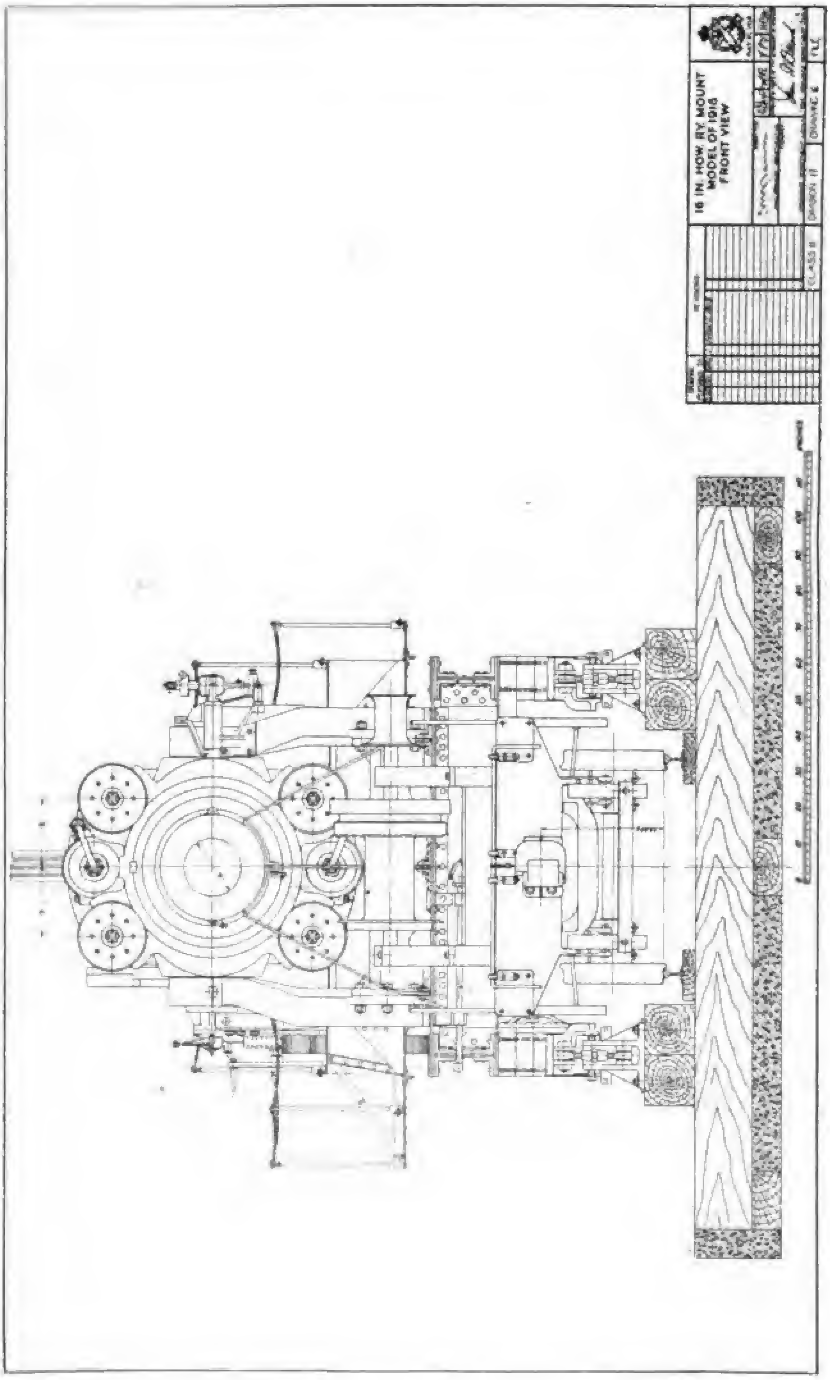

16 IN. HOW. RY MOUNT
MODEL OF 1918
FRONT VIEW
CLASS II
DIVISION 17
DRAWING 6
FILE

PLATE 355

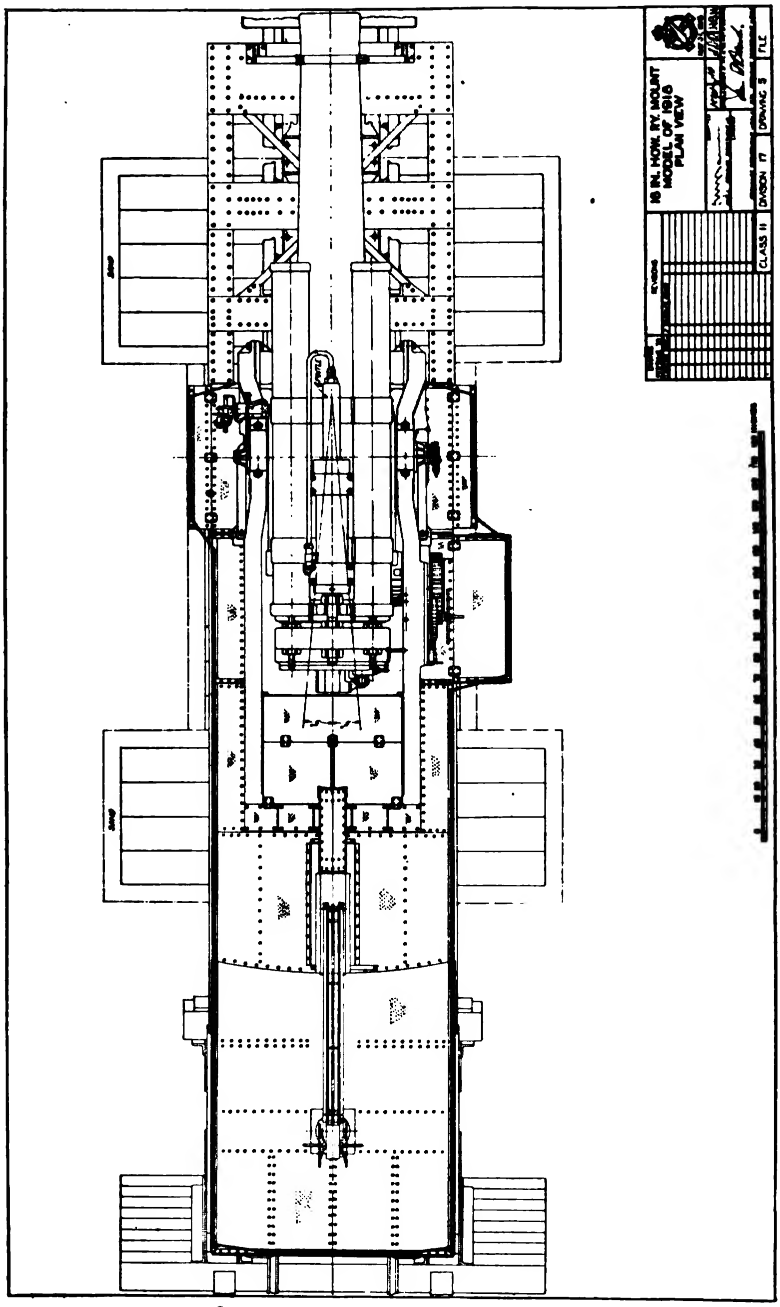

16 IN. HOW. RY. MOUNT
MODEL OF 1916
PLAN VIEW
CLASS II
DIVISION 17
DRAWING 5
FILE

Plate 356

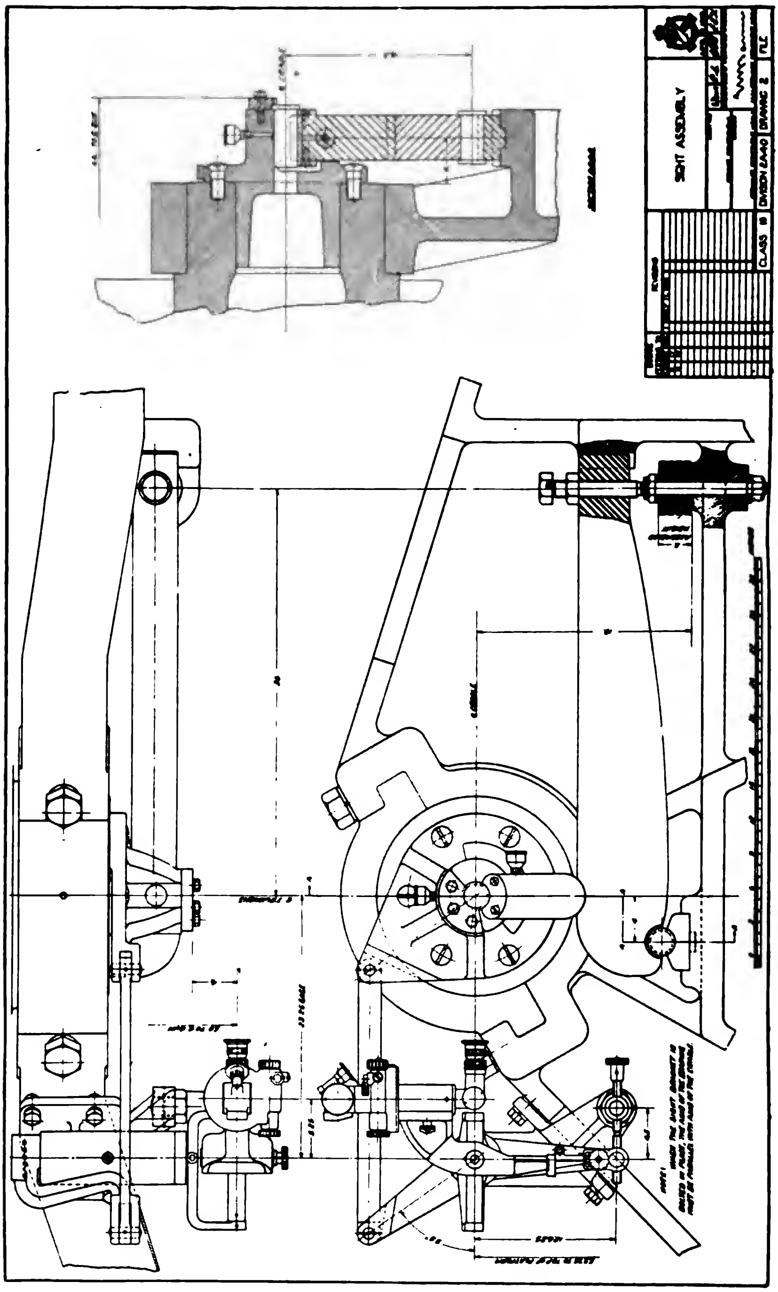


PLATE 35i

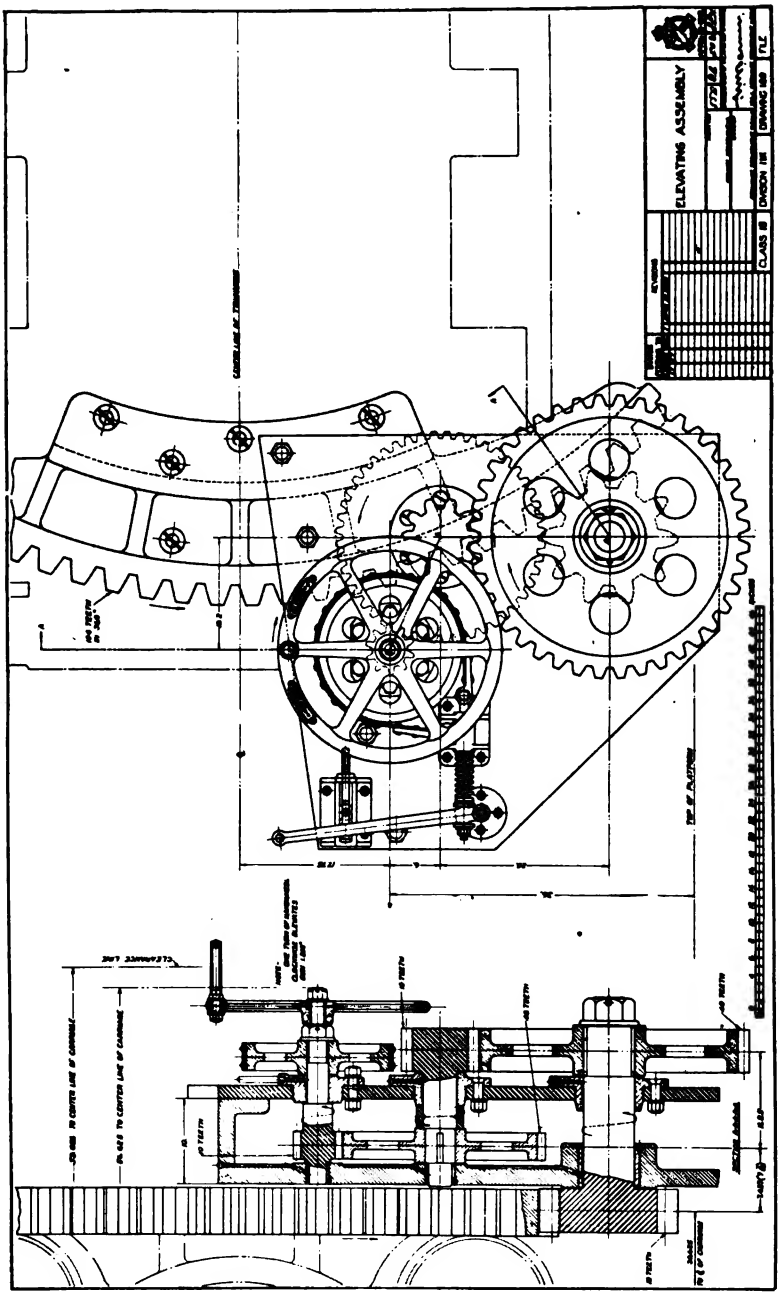


Plate 358

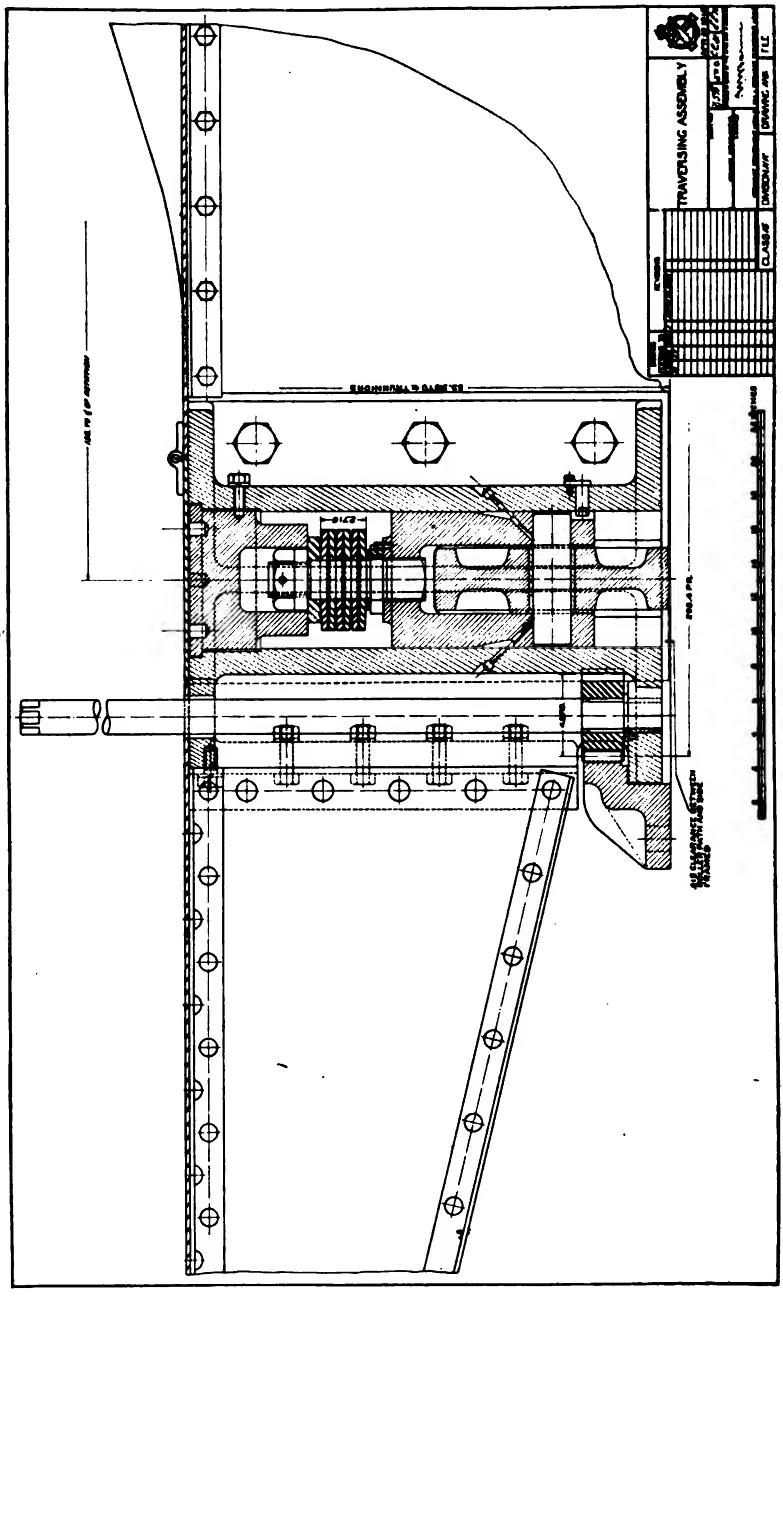


PLATE 359

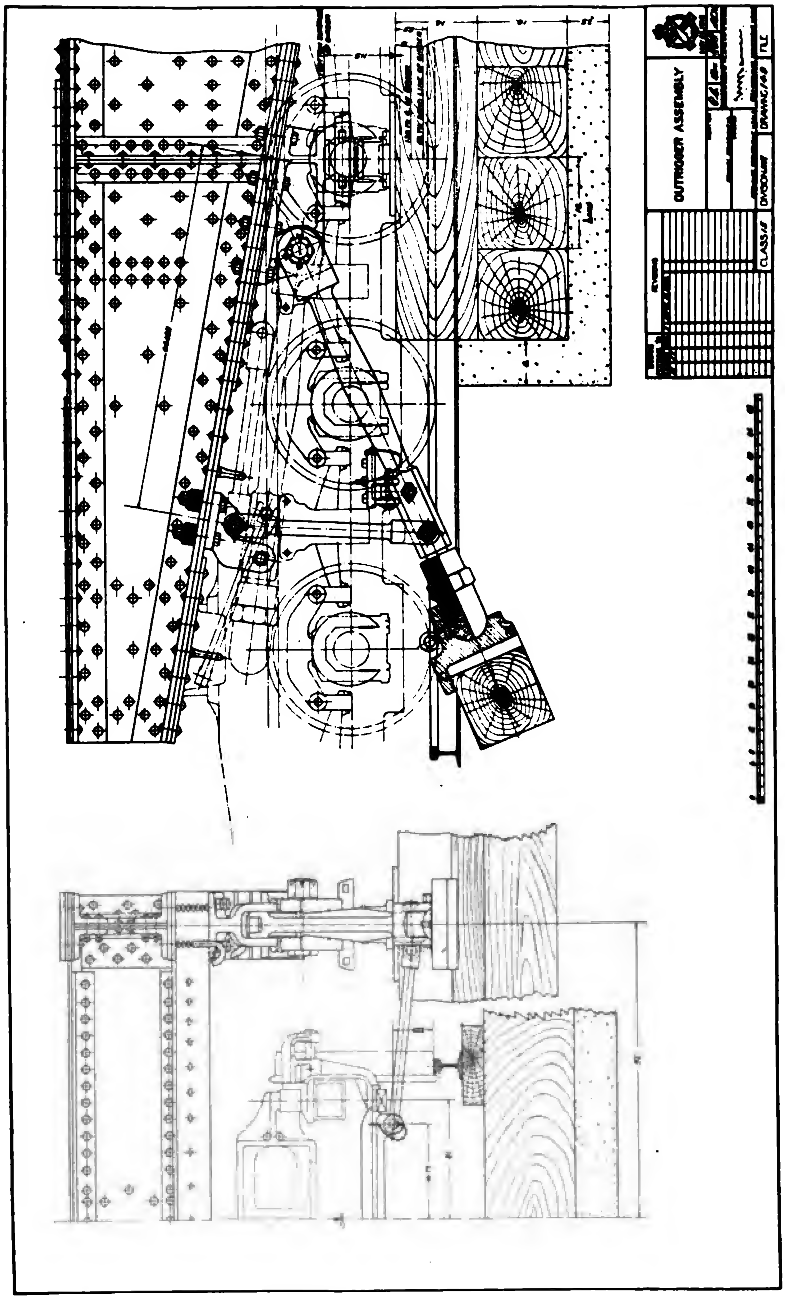


PLATE 360

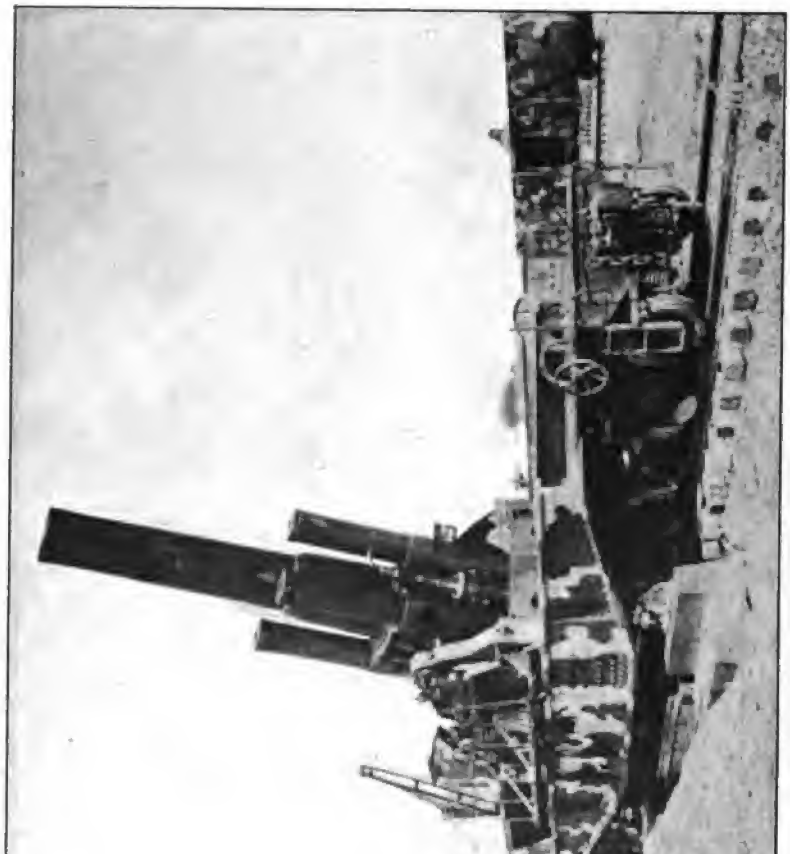


PLATE 361

16-INCH AMERICAN HOWITZER MOUNT, MODEL 1918 (EMPLACED FOR HIGH ANGLE FIRING).

16.—AMERICAN 16-INCH GUN ON RAILWAY MOUNT. (29)

305. The description that follows is of what represents perhaps a study rather than an actual design of a railway carriage for the 16-inch 50-caliber American Army gun. It was made up during tht early summer of 1918, in anticipation of a need for such equipmene in France, and it is probable that the actual design would have followed very closely if not exactly these studies if it had been decided to construct such a mount. The mount is of the combined cradle rolling recoil type and is composed of a symmetrical structural steel girder carrying a unique type of top carriage by which it is possible to elevate the center line of the trunnions of the gun 40 inches above the traveling position, and the whole is supported on four six-axle trucks, plate 363. This represents the first known study of a mount in which provision is made for elevating the trunnions of the gun in this particular manner. The trunnions are mounted so close to the breech of the gun as to necessitate a counterbalancing arrangement to compensate for the considerable muzzle preponderance. It is necessary to operate the mount on a curved track to secure any considerable degree of traverse, but car body traversing mechanisms somewhat similar to those incorporated in the 14-inch carriages, models 1918 and 1919, are incorporated in the front and rear of the mount over each span bolster. The gun can be fired to a maximum elevation of 40 degrees without any other track preparation than the construction of a heavily ballasted curved track made of the heaviest rails and ties.

306. Accessory crane equipment, transporting cars, etc., plate 364, were to be provided for removing the gun and cradle from the mount and carrying it on a separate transport car. With the very large cradle that it was necessary to provide for this gun it was impossible to keep the mount, with the gun and cradle mounted on it, entirely within the clearance lines of all railways in France over which the mount would probably have had to operate. It would be possible to transport the mount complete over practically all the main lines of American railways.

307. The need for such a mount was very carefully considered in France and it was finally decided that such a unit would not be either an efficient or economical competitor of the bombing plane. It was felt that in consideration of the difficulties involved in transporting such a mount over roads which were not always in the best of condition, and in consideration likewise of the fact that the accuracy of fire of such a gun at its maximum range would not be such as to make it possible to operate effectively against any targets smaller than a large railway yard or a city, both of which could be operated against more effectively both as to accuracy in placing the explosive charges and as to the extent of destruction, by bombing planes, it would not be wise to divert our limited manufacturing facilities from absolutely essential ordnance to this experiment.

308. In the autumn of 1918 the Navy Department, on finding that the axles of the 14-inch mount, Mark I, were so heavily loaded

as to give continual trouble from overheated journals, designed and began the construction of a mount whose characteristics were almost identical with this 16-inch mount. This mount, which is termed the Navy 14-inch Mark II mount, has since been finished. Its total weight is such as to require only 20 axles as against 24 for the 16-inch mount.

309. Gun.—The gun for which this mount was to be designed is the 16-inch, model E, of 50-caliber length. It is fitted with splines above and below, which slide in spline ways in the cradle to prevent rotation of the gun, and a heavy lug or yoke is shrunk on over the breech, to which lug the four recoil and two recuperator pistons are attached. The gun is rifled with 144 grooves which twist to the right at a pitch increasing from one turn in 50 calibers to one turn in 25 calibers. The breech is of the Welin or stepped thread type and is equipped with a mechanical firing mechanism.

310. Recoil Mechanism.—The recoil mechanism is of the hydropneumatic type and comprises four hydraulic recoil cylinders arranged symmetrically about the cradle, two above and two below, and two pneumatic recuperators, placed one in the center at the top of the cradle and the other in the center at the bottom. The normal length of recoil is 48 inches and the maximum length of recoil is 49.67 inches. The mount itself is likewise of the rolling recoil type and while some of the energy of recoil is dissipated in the recoil mechanism proper, most of it is absorbed in the friction of the brakes as the mount rolls back on the track. Most rolling recoil mounts that have been observed roll back on the track a distance of from 30 to 50 feet. It is assumed that this might represent the probable length of recoil of this mount also. The design of the recoil cylinders is practically the same as that of the recoil cylinders of the mounts already described. The design of the pneumatic recuperators is practically identical with that of the pneumatic recuperators used on the 12-inch mortar and the 12-inch Batignolles mounts.

311. Elevating Mechanism.—Elevation is provided from minus 3.3 degrees, the loading angle, to plus 40 degrees, the maximum firing angle. The mechanism comprises two worm racks, worms meshing with these, and a series of bevel and spur gears leading to the driving motor and to the handwheels on either side of the mount. The mechanism is driven by an electric motor under normal conditions, but provision was made for hand operation in the event that this should at any time be necessary. Provision is made likewise for disengaging the worms from the elevating racks when the gun is in transporting position. An accessory to this mechanism is the compensating cylinder shown on plate 364, directly below the trunnions. It was necessary to place the trunnions close to the breech. This resulted in a large muzzle preponderance, which is compensated for by the balancing cylinder. This compensating arrangement is an adaptation of the pneumatic recuperator and consists of a cylinder placed within a larger cylinder, the inner cylinder sliding in and out as the gun is depressed or elevated. Tie-rods connect the front of the inner cylinder with the bottom of the cradle. The stroke of the

inner cylinder or piston is 75.52 inches, and the maximum pressure in the cylinder is 1,950 pounds.

312. TRAVERSING MECHANISM.—It is necessary to operate this mount on a curved track to secure any considerable traverse. Electrically driven translating mechanisms similar in design to those used on the 14-inch mounts, models 1918 and 1919, are incorporated in the trucks, for the purpose of training the gun on the curved track. It is quite probable, however, that the mount would ordinarily be returned to battery by a locomotive, inasmuch as the length of recoil of from 30 to 50 feet is so great as to make the time necessary to return it by means of the translating mechanisms excessive. An additional mechanism is incorporated in the mount at either end over the center of the span bolsters. This mechanism is of a design similar in principle to those mechanisms used on the 14-inch mounts, models 1918 and 1919, and affords a total traverse of 1.3 degrees.

313. GUN CARRIAGE.—The gun carriage comprises a cradle of gridiron design with its four recoil and two recuperator cylinders and the cast-steel slide, by means of which the gun can be elevated 40 inches for firing. This slide is composed of two cast-steel side members joined by transoms, plate 364, and carries the cradle by means of trunnions resting in the bearings machined in the top. The carriage is raised a distance of 40 inches by means of eight hydraulic jacks. The pressure necessary in these jacks is approximately 2,100 pounds per square inch. When either at its upper or lower position the carriage is fixed rigidly to the car body by means of four large pins inserted through the side girders and the carriage castings. Additional safety devices are provided at the front and rear of this carriage on top of the side girders in the shape of screw-operated cast-steel supports, which can be run under the extensions of the carriage, thereby relieving the pins from excessive load. The carriage castings have four pin holes, the top ones of which are used when the gun is transported and the lower ones of which are used when the gun is in battery position. The carriage slides between the webs of the side girders on fixed grooved guides. The slides or supports mentioned above are provided with stepped surfaces which are intended to serve as supports when the carriage is being raised.

314. CAR BODY.—The car body is composed of two single web structural steel girders joined by a series of structural and cast-steel transoms and supported at the front and the rear on the trucks by means of span bolsters. The construction of the girders is symmetrical about a vertical center line.

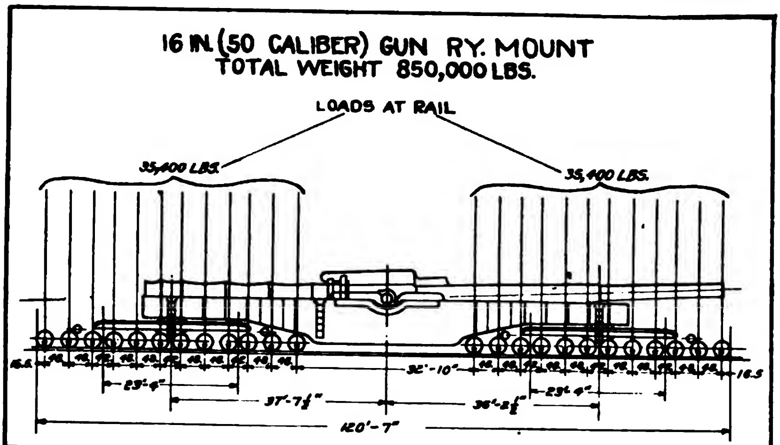
315. ANCHORAGE.—The only anchorage that this mount has in firing is the friction of the brakes. It rolls back a distance of approximately 40 feet on the track. The brakes must then be released and the mount is returned to its firing position by the translating mechanism or by a locomotive.

316. TRUCKS.—The trucks are four in number, of locomotive type, and cor[illegible] each with 6.5 by 12-inch journals and 33-inch steel w[illegible]des of each truck are equalized throughout so

that the load is distributed as perfectly as possible. They are equipped with semielliptical springs of sufficient capacity to stand both the transporting and the firing load. The mount is supported on these trucks in pairs by means of structural steel span bolsters. The center bearings of these bolsters are of the roller type.

317. Ammunition Supply System.—It is not certain whether the standard railway artillery ammunition car could have been used with this mount. If not, a car of similar design but of heavier construction would have been provided. The loading mechanism is of a design similar to that provided on the 14-inch mounts, models 1918 and 1919. The loading position of the gun is minus 3.3 degrees, and the loaded tray acquires sufficient velocity on the inclined track to cause the projectile to slide into the powder chamber. The projectile is rammed by hand.

Plate 362



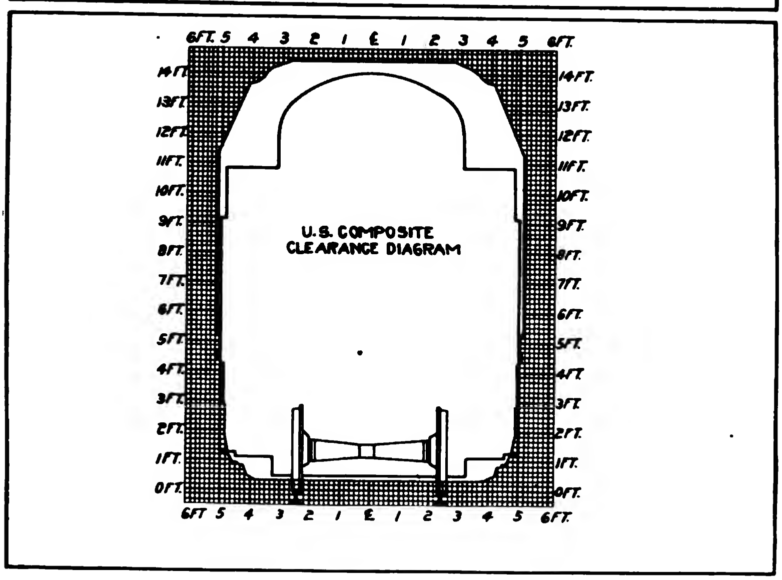
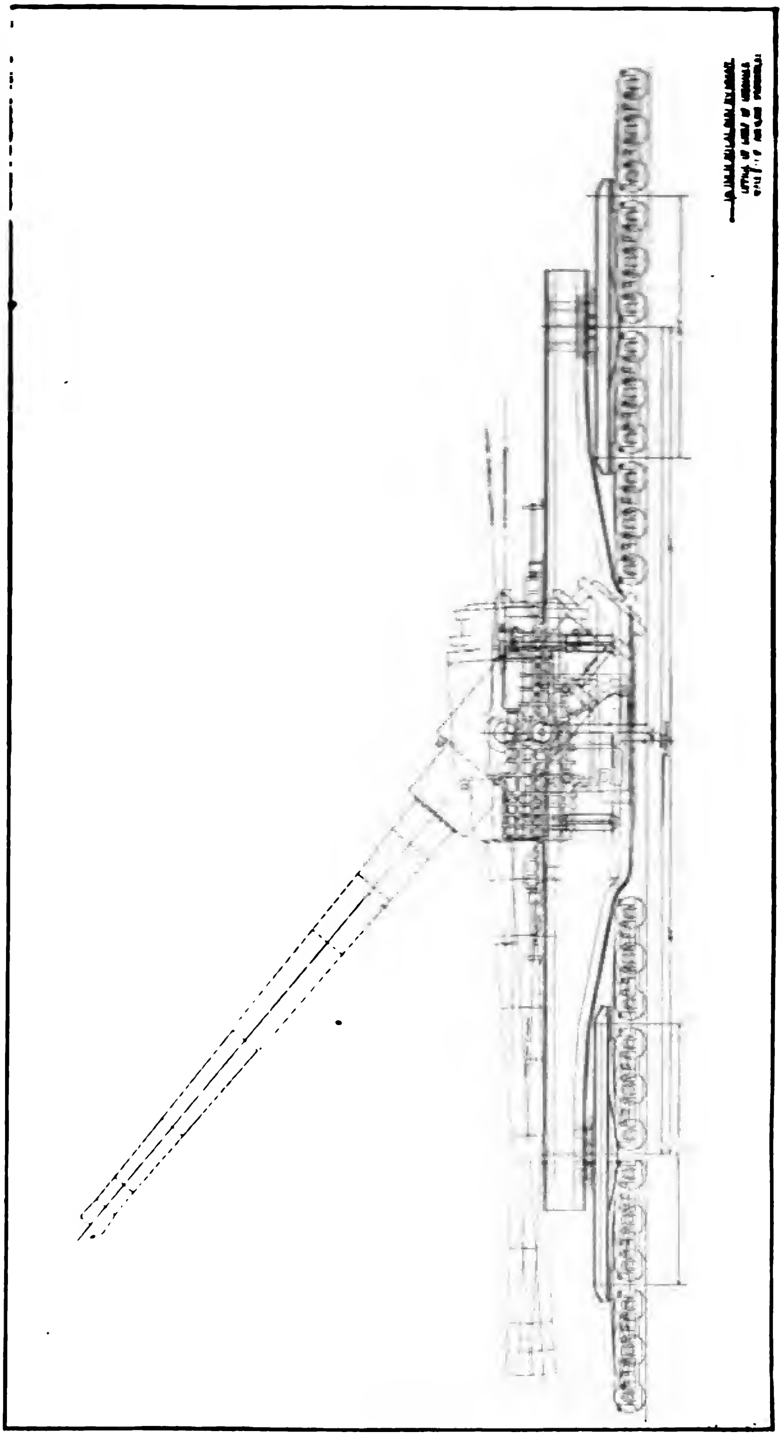
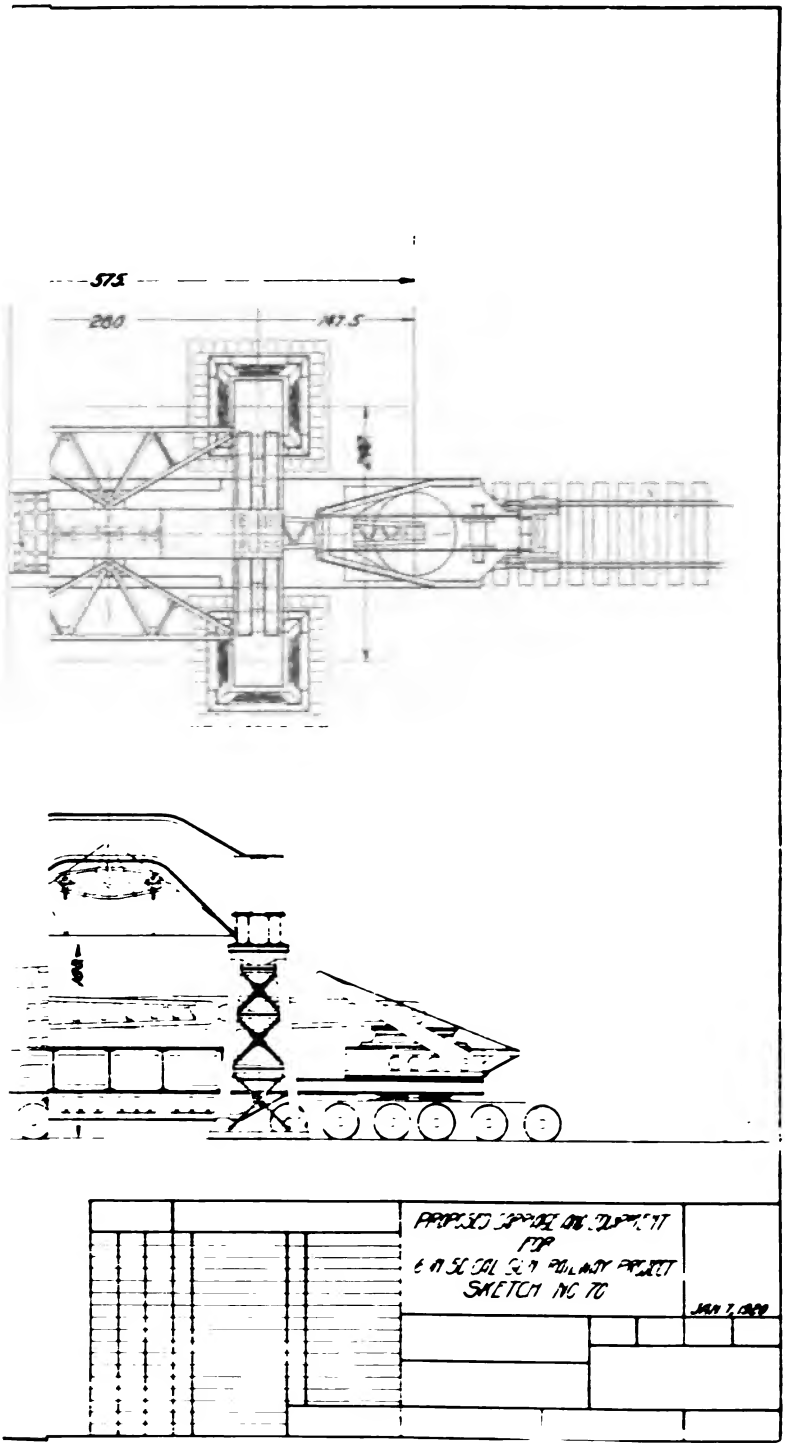


PLATE [illegible]




57.5
28.0
147.5
FOR
SKETCH NO 70

17.—GERMAN 170-MILLIMETER GUN, MODEL 1915, ON RAILWAY MOUNT. (30)

318. This mount is a combination arranged for use as a railway mount firing from the wheels with small traverse or as an emplacement mount firing from a platform with all-round traverse. It is made up of a heavy type of mobile gun carriage set on a special drop frame flat car. The gun carriage is quite similar in design to the German field carriage mounting 15-centimeter 40-caliber guns and may be operated from the same type of platform. The mount is shown on plates 365 to 371. The car trucks of the mount examined bear the date 1917.

319. GUN.—The gun is a modern Navy piece, model 1915, of 40 calibers length. It is rifled with 52 grooves twisting to the right at uniform pitch of 1 centimeter in 10 centimeters. It is provided with the ordinary type of Krupp sliding wedge breechblock and uses semifixed ammunition.

320. RECOIL MECHANISM.—The recoil mechanism is of the hydrospring type and comprises one hydraulic brake cylinder attached to the cradle in the center at the bottom and two spring recuperator cylinders attached to the cradle on either side of the brake cylinder, plates 366 to 368. The length of recoil is 15 inches. Two round rods screwed into the recoil lug on either side of the brake piston rod extend to the rear and carry the yoke which is attached to the two spring piston rods.

321. ELEVATING MECHANISM.—The elevating mechanism comprises a rack bolted to the left side of the cradle and a pinion with a worm wheel, worm and bevel gears leading to a handwheel. Another handwheel, or rather a crank of 12-inch radius for high speed elevating, is connected to the first through a sprocket and chain. Sudden shocks of fire appear to be taken care of by Belleville washers on the worm shaft, which allow it a slight motion in an axial direction. This entire mechanism is disposed along the left side of the carriage and can be traced out in plate 366. A total elevation of 45 degrees is indicated on the elevation scale, although a publication at hand states that 47.5 degrees is possible. The first, or adjusting handwheel, gives a ratio of 0.4 degree per turn of handwheel, while the second at the end of the chain, for rapid movement, gives 1.25 degrees per turn. No antifriction trunnions are provided and the operation of the second handwheel even at slow speed is hard work for two men.

322. TRAVERSING MECHANISM.—As noted above, traverse is obtained by moving the field carriage upon the railway car. The carriage is kept in place by means of an angle-iron circle fastened to the flat car floor and around which the wheels of the mount can roll,

plate 236. At the center of this circle is a large pin, fastened to the car, from which swiveled tension rods extend back to the trail of the carriage. The gun carriage wheels bear against the circle of angles and prevent sidewise movement, while the rods prevent lengthwise movement, but the carriage is free to roll on its own wheels about the pivot. The two large wheels of the carriage are about 6 feet in diameter with 19.5 inch face, of which the center 7.75 inches is raised 2 inches higher than the remainder. These wheels are made, both rim and spokes, of structural material, generally of channel section.

323. The rear end of the trail of the carriage body rests.on the car floor and against a circular rail fastened thereto, plate 368. On the outside of this rail there is a series of pins, forming a rack, into which a star wheel fastened to the trail meshes. This star wheel is operated through a worm, horizontal shaft, and bevel gear, from a handwheel located near the trunnions on the right-hand flask of the trail. The weight of the trail during traversing is carried upon two spring-supported rollers, which give under the shock of fire and allow the trail to rest directly on the car floor. Twenty-six degrees total traverse is allowed and the gun is moved 0.167 degree per turn of handwheel.

324. Gun Carriage.—The gun carriage is very much like that provided for the British and American 6-inch mobile guns and, as noted before, is quite similar to the German carriages mounting 15-centimeter guns. It comprises a cradle of naval design, plate 366, and a built-up structural steel body, plates 366 and 368. The cradle is carried on the body by means of two cast-steel trunnion bearings without any friction-reducing devices. The cradle is identical in design with those used on German ships and in their coast defense. There is a possibility that this is one of the guns removed from their second navy late in 1917. The body consists of two built-up structural flasks of channel sections with flanges 7 inches wide and a depth of web tapering, as shown on plate 366, from 38 inches in front to 13.5 inches at the extreme rear. The axle on which the wheels described under Traversing Mechanism are mounted is bolted to the bottom of the flasks.

325. Railway Car Body.—The railway car is a drop frame flat car of special and very strong construction. The side sills are built-up plate girders of very heavy and varying sections, plates 365 and 366. The entire body is decked with about 0.625-inch steel plate. Except for the very strong construction, there is nothing of special note about the car body.

326. Anchorage.—For firing at angles up to 13 degrees on each side of the center line of the track, cast-steel wedges are placed on the ties under corresponding wedges on the side sills and the mount

is moved by a locomotive until it is wedged up on these. See plate 366 for wedges under the side sills.

327. For wider traverse and other special service a field platform and foundation mounted on a special wagon on road wheels are carried on a flat car, plate 369.

328. The field platform foundation consists of four box girders of light steel, each about 20 by 35 inches and perhaps 10 feet long. At one end of each, two 1-inch steel plates are attached to the top and bottom and extend a foot or so beyond the end, plate 368. A large hole is formed in these to receive the pivot pin. A rigid equal-legged cross, which when buried in the ground constitutes the anchorage or foundation for the field platform, is formed by placing the girders radially, so that these holes match, inserting the pin, and putting in place between the girders some special I-beam spacers, plate 371.

329. The field platform, plate 370, consists of a forward member containing a hole for the pivot pin above mentioned and having formed at its sides guides for the carriage wheels similar to that formed by the circle of angles on the car. This is joined by radial structural members to a large steel plate on which the trail is intended to rest and which is equipped with a circular arc, inside of which the end of the trail rotates, and a chain into which the teeth of the star wheel can engage for traversing. This platform slips down on top of the foundation above described, and it can be pulled around into any desired direction for firing the gun. The gun is rolled onto this platform and the tiebars secured between the trail and the center pintle just as on the railway car. It can be rotated through a small angle, perhaps 10 degrees, upon the platform in any position, and for wider traverse the platform can be moved around any desired amount.

330. Trucks.—The trucks are of structural construction, two axles each, with semielliptic springs and no equalizers. The wheels are nearly a meter in diameter and have very light spokes. Each wheel has two brake shoes.

331. Ammunition Supply System.—The shells of this gun are sufficiently small so that they can be handled by two men with a tray. The tray employed is provided with eyes, which fasten to hooks on the breech of the gun. It is hooked in position and the projectile rammed from it.

332. Maintenance.—The sturdy construction of the car body as well as of the gun carriage itself, including the cradle and recoil mechanism, indicates that comparatively no difficulty would be experienced in maintaining this mount even under the hardest service and most difficult conditions. The semipermanent emplace-

ment is likewise of such sturdy construction that it is not probable that it would be damaged except with most careless handling.

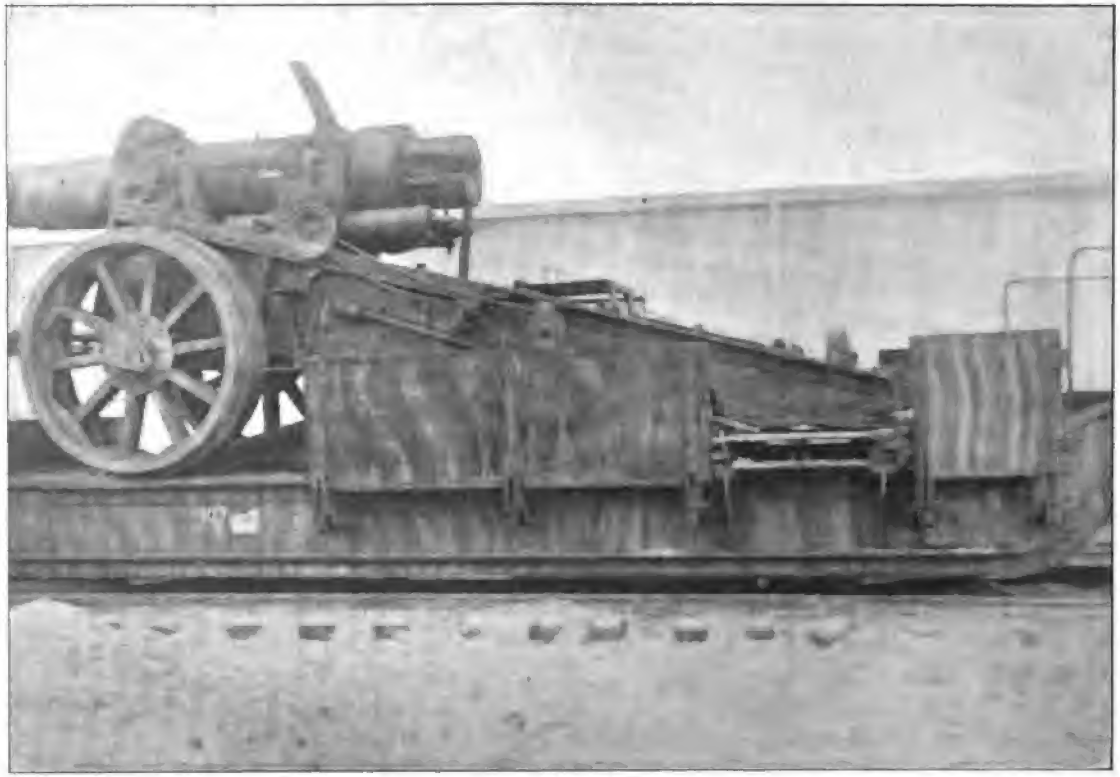
333. Difficulties Involved in Service.—The construction of this mount indicates that when serving as a railway mount it might be placed for firing in 10 or 15 minutes. The indications from the construction of the trucks are that the whole mount can be rendered sufficiently stable so that the personnel could remain on the car at all times and serve the gun with maximum speed, probably one shot per minute. From the standpoint of efficiency of service this improvisation certainly seems to fill the bill.

334. Merits.—The merits of this improvisation are its sturdy and simple construction, resulting in a minimum of maintenance, its exceedingly simple method of emplacement for firing from the rails, and the excellent and simple scheme of attaching the ammunition tray to the breech of the gun.

335. Demerits.—If one considers this mount simply from the standpoint of an improvisation it could not be said to have any demerits. Under "Trucks," it was mentioned that the wheels are of exceedingly light construction, but the fact that the car body rests on four wedges when the gun is fired and that when placing the car on these wedges the mount is likely raised considerably from the trucks would indicate that there would be no likelihood of breaking the wheels through shock of fire. From the standpoint of the Germans it would appear unfortunate that this mount had no greater traverse than 26 degrees in any one position on the track. It must be remembered, however, that it was an improvisation, built much more quickly than any type of all-round fire mount could have been made, and that probably the limited extent of traverse has been justified after all.

PLATE 365

170 MM. 40-CALIBER GERMAN GUN MOUNT.



CARRIAGE FOR THE 170 MM. GERMAN GUN (RECOIL AND ELEVATING MECHANISM).

PLATE 367

CENTER PIVOT AND TENSION RODS OF THE 170 MM. GERMAN GUN MOUNT.

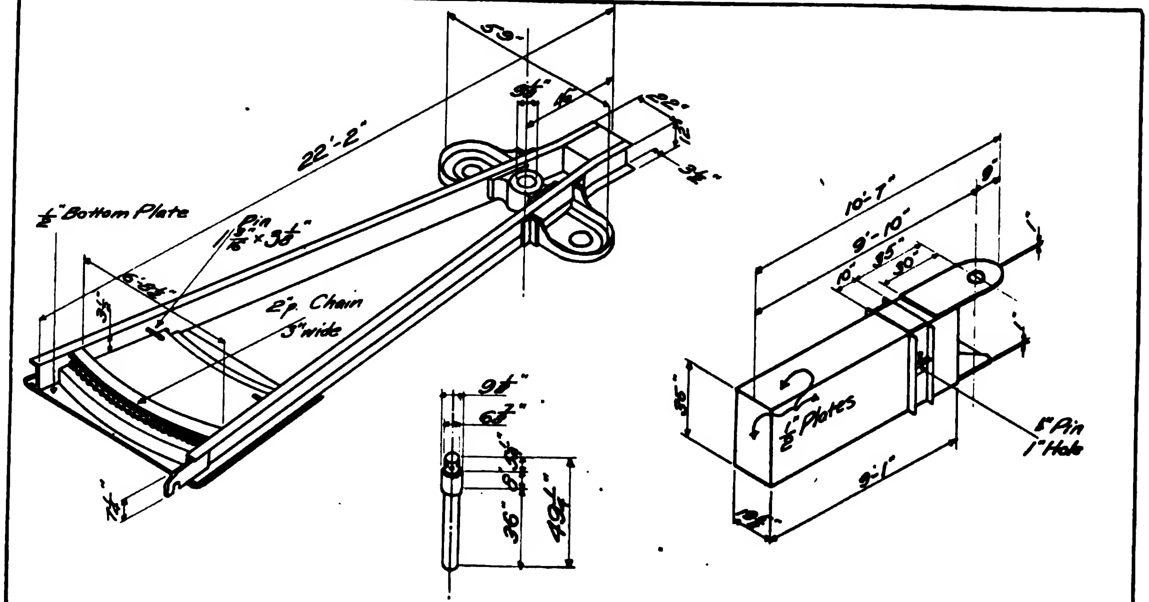
PLATE 368

TRAVERSING GEAR OF THE 170 MM. GERMAN GUN MOUNT.

Plate 369

FIELD PLATFORM OF THE 170 MM. GERMAN GUN MOUNT.

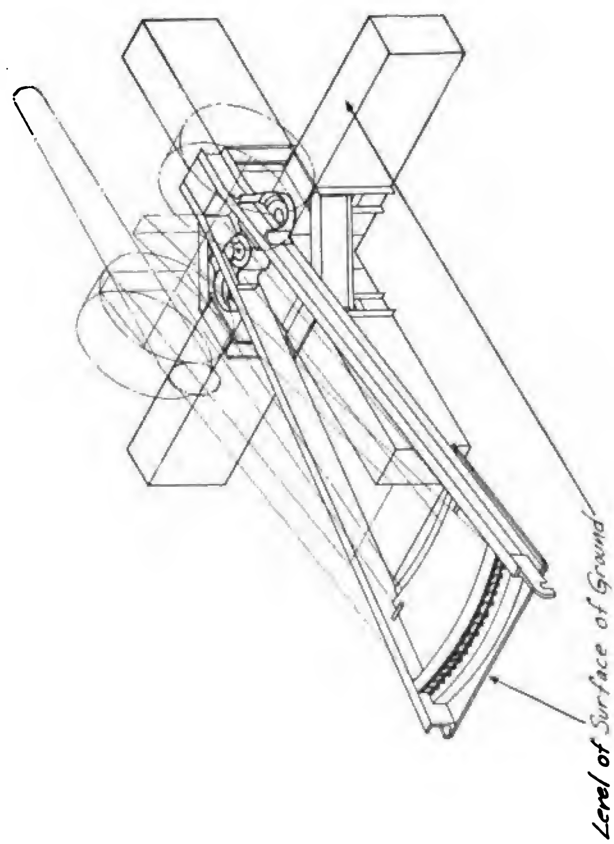
PLATE 370



Platform - 1. Center Pin - 1. Support Girder - 4.

Details of Field Platform.
17cm. German Gun, Model of 1915.

PLATE 371



Assembly of Field Platform.
17cm. German Gun, Mod. 1915.

18.—GERMAN 210-MILLIMETER GUN ON RAILWAY MOUNT.(31)

336. This mount is of the cradle recoil type, plate 372, firing either from the wheels with limited traverse or from a structural steel or reinforced concrete ground platform with all-round fire. It is similar in general type to the German 240 and 280 millimeter mounts, and all of them can be operated on the same ground platform.

337. GUN.—The gun is a modern naval piece, model 1913, of 31 feet total length, probably 45 calibers. The powder chamber is only a very little larger than the bore and semifixed ammunition is used. The tube is rifled with 64 grooves twisting to the right at a uniform pitch of 1 centimeter in 10 centimeters. The breechblock is of the ordinary Krupp sliding-wedge type and is fitted with a mechanical firing mechanism.

338. RECOIL MECHANISM.—The recoil mechanism is of the hydro-spring type and is composed of two hydraulic recoil cylinders mounted on the top and bottom of the cradle in the center and four spring recuperator cylinders mounted two on the top and two on the bottom of the cradle and on either side of the recoil cylinders, plates 373 and 374. Each recoil cylinder is attached to the cradle by a heavy pin, about which it can swivel in a vertical plane. The forward ends of the springs are connected to the recoil band by a stirrup and two tension rods each. The length of recoil is about 24 inches.

339. ELEVATING MECHANISM.—Elevation is provided from 0 degree, the loading angle, to 45 degrees. The elevating mechanism comprises two racks with inside teeth bolted to the bottom of the cradle, two pinions on a common shaft meshing with these, worm wheel, worm, bevel gears, and a special two-speed gear transmission leading to a handwheel. The double-speed gear is entirely similar to that on the 240-millimeter mount, shown in detail on plate 381. The worm and wheel can be seen on plate 375. The ratio of the gear for slow motion is 0.125 degree of elevation per turn of handwheel; for fast motion it is 1.50 degrees per turn. A roller-bearing, anti-friction device is provided on the trunnions, plate 372, which is similar in every way to that provided on the 280-millimeter mount and shown in detail on plate 388.

340. TRAVERSING MECHANISM.—Two traversing mechanisms are provided on this mount. The one is for the purpose of rotating the car body about the pintle of the front truck in firing from the track. It affords a total traverse of 2.25 degrees, or 1.12 degrees on each side of the center line. The other is for the purpose of rotating the mount around a center pivot which is fastened to a ground platform. This mechanism affords 360 degrees. The first mechanism is entirely similar to that employed with the 280-millimeter mount and shown on plates 370 and 391. It comprises a gear case bolted to the side

of the mount, a traversing beam housing bolted into the side girders over the center of the rear truck, and a traversing beam, which is likewise the upper center plate of the rear truck, sliding in guides in the housing. The traversing beam is moved with respect to the housing by a screw, plate 390, which in turn is driven by the handwheel through the gears in the case on the side of the mount. Since the beam is fixed with respect to the truck, any motion of the screw forces the housing and the rear of the mount to the right or left. An indicator is provided in the top of the gear case to show the extent of the traverse, and there is a lock for securing the mount in traveling.

341. The second mechanism comprises a center pivot and two rear support rollers, plate 376. The center pivot comprises a base, 70 inches in diameter, which bolts to the ground platform by twenty 2.5-inch bolts. This base contains a pintle about which the mount rotates and supports a ball bearing with sixteen 5-inch balls on which the swiveled racer carrying the mount rests. This pivot is identical in design with that of the 280-millimeter mount, plate 394. The racer is carried by means of its trunnions in steel bearings bolted to the bottoms of the side girders. Thus the car body can rock in a vertical plane as well as rotate in a horizontal plane about the base. The rear end of the mount is supported on a track in the foundation by two rollers, 24 inches in diameter by 4 inches on the face, the housings of which are bolted to the side girders just forward of the rear truck. These are set on a radius of 14 feet 9 inches from the center pivot. One of these rollers is provided with gearing, plate 376, through which it may be driven by one two-man handle. Twenty-four turns of the handle give one revolution of the roller. This is equivalent to about 1 degree of traverse per turn of the handle.

342. Gun Carriage.—The gun carriage and car body are one in this mount and will be jointly discussed in the next paragraph.

343. Railway Car Body.—The gun is carried in a cylindrical cast-steel cradle, about 9 feet long, which is supported in cast-steel bearings on the side girders of the car body by means of trunnions about 10 inches in diameter by 7 inches long. The railway car body consists of two single web plate girders, built up of about 0.625-inch plate, and 5 by 5 inch angles with cover plates. The depth of these girders is about 52 inches at the center, 28 inches over the front trucks, and 34 inches over the rear trucks. Structural steel transoms are employed throughout and the bracing against skew consists of a decking of about 0.625-inch plate over the two trucks and against the underside of the girder. As shown on plate 372, a number of folding platforms are provided along the sides of the mount. and a cab of 0.5-inch armor plate is provided around the breech of the gun to protect the personnel. Special I beams are supported under the

front and rear ends of the girder for use in jacking the mount off the trucks and letting it down on the foundation. The girder rests on these beams through roller bearings; adjusting screws are provided to facilitate exact adjustment of the bolt holes in the pivot flange with those in the foundation.

344. ANCHORAGE.—This mount must be operated on a curved track to secure wide traverse when it is fired from the wheels. Special wedges made in identical halves are bolted to the rails behind each wheel by one bolt each. These wedges are about 12 inches long by 6 inches high at the rear and are curved to fit the circumference of the wheel. The ground platform employed to secure all-round fire is identical in design with that shown on plates 397, 55, and 56. The mount is run into place on the platform and the small section of track over the center, as shown in the upper view, plate 397, is removed in order that the pivot base may be lowered on to the structural base by means of the lowering screw, plate 394. It is bolted fast by 21 bolts. Four special jacks of a design shown on plate 398, and attached to the jacking beams located under the front and rear of the mount and described in the preceding paragraph, are then let down and the mount is raised by means of them sufficiently to permit the trucks to be removed as well as the two sections of track connecting the center with the outside. The entire mount is then lowered until the rear rests on the circular track by means of the rollers and the forward end rests on the 16 steel balls in the central pivot.

345. TRUCKS.—The trucks are of structural steel construction throughout with four axles each, outside journals, semi-elliptical springs and equalizers between outside axles only, plate 372. A capstan headed screw is provided over each journal bearing and is so arranged that it can be screwed down on to the spring clip and relieve the springs of undue strains when the mount is fired from the wheels. Hand brakes only are provided.

346. AMMUNITION SUPPLY SYSTEM.—An overhead trolley runs on an I-beam track secured along the top of the cab. An extension beam is so hinged to the fixed beam that it can swing in a vertical plane, can be lowered for traveling or raised and braced in place to allow picking up a shell from a car or from the track some distance behind the mount. The extensible trolley arrangement of the 240-millimeter mount, plate 378, is identical in design. The shot tray is provided with two two-man handles, a yoke above with an eye, and four wheels below, so that it can be carried by the trolley hoist, by hand, or rolled on the floor. It can be hooked in place on the breech as with the 17-centimeter mount, plate 373.

347. MAINTENANCE.—There are no apparent difficulties in the maintenance of this design of railway mount, which, as mentioned

before, has been used for 24-centimeter guns and howitzers and 28-centimeter guns. All parts are very simple in design and substantially constructed. The elevating, traversing, and loading mechanisms had all seen considerable service and no apparent difficulties had developed. The trucks had likewise given no difficulty. The speed transmission introduced in the elevating mechanism of this and the 24-centimeter mount is very sturdy in construction and apparently did not give any trouble.

348. Difficulties Involved in Service.—But one difficulty is apparent in the service of this mount. This difficulty results from the necessity for using a heavy platform, usually of steel, which likely requires from three to six days for placing. Without this traversing mechanism it is, of course, necessary to operate the carriage on a curved track, making the necessary small adjustments in azimuth by the traversing mechanism on the rear truck. The use of this steel platform necessitates the providing of a knockdown Gantry crane, and seven cars are required to carry the crane and platform.

349. Merits.—The double speed transmission on the elevating mechanism is simple in design and very effective. The design of the traversing mechanism is good. The mount requires either a structural steel or reenforced concrete platform, both of which require some time for installation, but in comparison with other mounts now in existence, this design must be considered good. This is the first mount on which so simple and effective a type of anti-friction device has been used and it deserves consideration for our own work of design. The traversing mechanism installed over the rear truck is simple in design and excellent for service in firing from the track. The scheme of attaching the loading tray is simple and excellent and warrants consideration. It may be well to mention that although the ground platform of this requires some time for its installation, it is neverthheless easy to conceal after it is installed, since the approach tracks may be removed and the mount completely covered.

350. Demerits.—The one apparently bad feature which has been mentioned likewise under the head of Merits, is the firing platform. At the beginning of this section it was mentioned that criticism would be made of the firing platform on a basis of the ideal apparently attainable. The steel platform, however, required seven cars for its transportation and can not be installed in less than from three to five days. The concrete platform can probably be installed in the same length of time and of course, with fewer facilities. It seems possible to design a mount in which the same general features may be embodied but which will not require such elaborate accessory equipment in the shape of a platform as is used here.

PLATE 372

210 MM. GERMAN GUN ON RAILWAY MOUNT (MODEL 1913).

PLATE 373

BREECH MECHANISM AND LOADING APPARATUS OF THE 210-MM. GERMAN MOUNT.

PLATE 374

CRADLE, RECOIL CYLINDER, AND SPRING RECUPERATORS OF THE 210-MM. GERMAN GUN MOUNT.

PLATE 375

CENTER PIVOT, ELEVATING WORM, AND ANTI-FRICTION BEARING OF THE 210-MM. GERMAN GUN MOUNT.

PLATE 376

CENTER PIVOT AND TRAVERSING MECHANISMS OF THE 210-MM. GERMAN GUN MOUNT.

19.—GERMAN 240-MILLIMETER HOWITZER ON RAILWAY MOUNT.(32)

351. This mount is of the cradle recoil type, firing either from the wheels with limited traverse or from a structural steel or reenforced concrete platform with all round fire. It is of the same general type as the 210-millimeter mount just described and only the differences between the two mounts will be described in detail. The mount examined bears the date "Essen 1918." It is illustrated on plates 377 to 383. Apparently, the mount was designed for a 240-millimeter gun, since the counterweight provided on the top of the cradle gives evidence of being a recent improvisation placed there to compensate for the difference in weight forward of the trunnions, between the gun and howitzer now mounted on it.

352. Gun.—The howitzer is a naval piece of 30 calibers over-all length and uses semi-fixed ammunition. The tube is rifled with 52 grooves twisting to the right at a uniform pitch of 1 centimeter in 10 centimeters. The breech block is of the Krupp sliding wedge type and is provided with a high-pitch screw for closing and a low-pitch screw for locking. The breech block is fitted with a mechanical firing mechanism.

353. Recoil Mechanism.—The recoil mechanism is of the hydro-pneumatic type and comprises two hydraulic recoil cylinders set into the cradle in the upper corners, and a pneumatic recuperator attached to the cradle in the center at the bottom. The pistons of the recoil cylinders are attached to the recoil band as shown on plate 379 and the forward end of the recuperator piston is connected with the bottom of the recoil band by means of a cross head and two tension rods, plate 380. The length of recoil is about 1 meter. The striking feature of this mechanism is the recuperator. The piston is a hollow plunger of uniform diameter facing the air directly and the packing which holds the air in, consists of four U-shaped leathers only. When the recuperator was disassembled, it had been standing for months without recharging but it still contained a very high pressure of air. The indicator was broken and it is not known exactly what the pressure was. The recoil band of this howitzer is made in halves and is bolted on, as shown in plates 379 and 380.

354. Elevating Mechanism.—This mechanism is similar in general design to that on the 210-millimeter mount. The differences are that the main racks, plate 380, have outside instead of inside teeth and are of much wider face. An antifriction device of the rolling wedge type, plate 382, is employed. The double-speed transmission on the elevating gear, plate 381, is identical in design with that used on the 210-millimeter mount.

355. Traversing Mechanism.—Two systems of a design almost identical with those used on the 210-millimeter mount are provided.

The noticeable differences are that the truck traversing mechanism gives 2 degrees on each side of the center or 4 degrees total as against 2 degrees on the 210-millimeter mount, and the rear traversing rollers are housed in and geared together.

356. GUN CARRIAGE.—The gun carriage is incorporated with the car body and is described in the next paragraph.

357. RAILWAY CAR BODY.—The gun is carried in a cradle of curious boxlike design, 45 inches by 52 inches by 105 inches, built up of castings and planed plates, plate 377. This cradle is suspended by means of its trunnions in cast-steel bearings mounted on the side girders of the car. As mentioned before, apparently the mount was originally designed for a 24-centimeter gun. Counterweights mounted above and below the gun and forward of the trunnions, plate 377, have apparently been added recently to compensate for the difference in the muzzle weight of the gun and howitzer. This cradle carries the recoil cylinders in its upper corners and the recuperator cylinders in the center at the bottom. The car body is similar in general design to that of the 210-millimeter mount, but differs considerably in its details. The car body is made up of two single web structural steel side girders connected by a number of structural steel transoms. Jacking beams are incorporated in the car body at the forward and rear ends, plates 377 and 383. These side girders are 39 inches deep over the front and rear trucks as against 28 inches for the 21-centimeter. This mount is likewise more liberally supplied with armor than the 21-centimeter mount.

358. ANCHORAGE.—See "Anchorage" under the 210-millimeter mount.

359. TRUCKS.—See "Trucks" under the 210-millimeter mount. They are identical.

360. AMMUNITION SUPPLY SYSTEM.—This is practically identical with that of the 210-millimeter mount, with the exception that the tray is not supplied with wheels and apparently is not used in carrying the shell. The shell is carried forward by means of the tongs, plate 392, and placed on the tray which is hooked to the breech of the gun.

361. MAINTENANCE.—See "Maintenance" for the 210-millimeter mount. Some additional maintenance probably results from the use of a pneumatic recuperator.

362. DIFFICULTIES INVOLVED IN THE SERVICE.—See the same for the 210-millimeter mount.

363. MERITS.—See "Merits" for the 210-millimeter mount. The one exception is in the case of the antifriction device of the rolling wedge type, which does not appear to be so admirable a design as the roller bearing.

364. Demerits.—See "Demerits" for the 210-millimeter mount. Additional criticisms may probably be made on the construction of the cradle. On further study it might develop that there are some advantages in the use of this quite clumsy looking cradle, but none are apparent now. It is possible that this cradle is an improvisation and was so constructed as to avoid the making and machining of a large casting.

365. Although it possibly has no place here, it may be well to mention that, in these three mounts, the 210-millimeter, the 240-millimeter, and the 280-millimeter, there are a great many differences in the design of details that do not seem to have any logical explanation. On the 240-millimeter mount the traversing rollers are housed and geared together, the elevating rack meshes on the outside, and antifriction device is of the rolling-wedge type, and the rear truck traverse is 4 degrees. On the 210-millimeter mount the traversing rollers are neither housed nor geared together, the elevating rack meshes on the inside, the antifriction device is of the roller type, and the rear truck traverse is 2.25 degrees. On the 280-millimeter mount the traversing rollers are housed and geared together, the elevating rack is straight, the antifriction device is of the roller type, and the rear truck traverse is 2 degrees. Apparently the three mounts can be operated on the same platform. Just why these minor variations in design were made is not at all evident.

PLATE 377

240-MM. GERMAN HOWITZER ON RAILWAY MOUNT.

PLATE 378

240-MM. GERMAN HOWITZER ON RAILWAY MOUNT (REAR VIEW).

PLATE 379

BREECH, CRADLE, AND LOADING TRAY OF THE 240-MM. GERMAN HOWITZER.

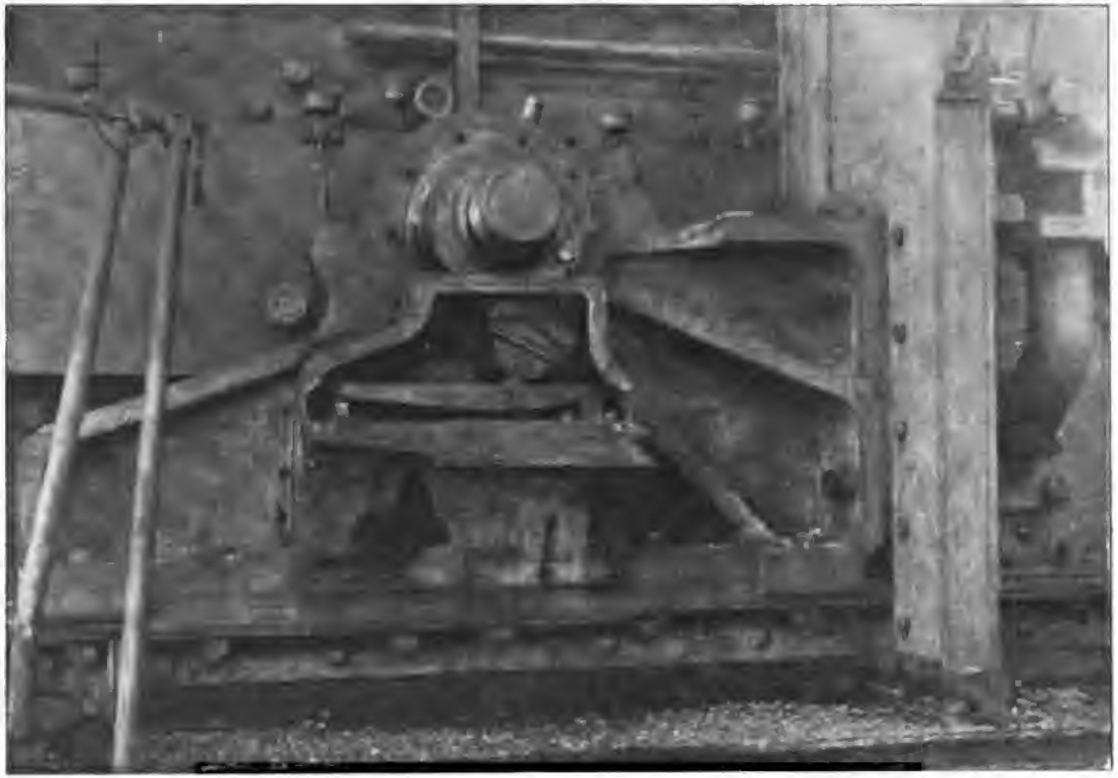
PLATE 380

ELEVATING RACK AND RECUPERATOR OF THE 240-MM. GERMAN HOWITZER.

PLATE 381

ELEVATING MECHANISM, DOUBLE-SPEED TRANSMISSION GEAR OF THE 240-MM. GERMAN HOWITZER MOUNT.

PLATE 382



ANTI-FRICTION BEARING OF THE 240-MM. GERMAN HOWITZER MOUNT.

PLATE 383

TRUCK TRAVERSING MECHANISM AND JACKING BEAM OF THE 240-MM. GERMAN HOWITZER MOUNT.

20.—GERMAN 240-MILLIMETER GUN ON RAILWAY MOUNT. (33)

366. On plate 384 a 240-millimeter gun is shown on a type of railway mount resembling more the 38-centimeter mount than the design used with the 21 and 24 centimeter mounts already described in detail. The writer has not had an opportunity to examine a mount of this type and to the best of his knowledge none of them were captured. No attempt will be made to describe it in detail. Attention is called to certain features easily seen on this plate. The mount is carried on two four-axle trucks, the axles having inside journals. This is the first German mount observed on which inside journals have been used. On the horizontal portion of the lower cords of the side girders a number of plates which appear to be key plates can be seen, and it is assumed that this mount was operated on a turntable type of emplacement somewhat similar in design to that used with the 38-centimeter railway mount. It is probable that the key plates mentioned engaged with similar plates on the racer of the emplacement. It is probable that hydraulic jacks were placed under the four corners of the car body after it was in position over the emplacement to raise the mount for the purpose of removing the trucks.

PLATE 384

240-MM. GERMAN GUN ON RAILWAY MOUNT.

21.—GERMAN 280-MILLIMETER GUN ON RAILWAY MOUNT. (34)

367. This mount is of the cradle recoil car traverse type, firing either from the wheels with limited traverse or from a structural steel or reinforced concrete ground platform with all round fire. It is similar in type to the 210-millimeter gun and 240-millimeter howitzer mounts already described and operates from the same ground platform. Three batteries of these mounts operated from concrete platforms were included in the German defenses on the coast of Belgium. (See Appendix III for description of these.) The mount examined and illustrated herein was captured by the British Fourth Army before Amiens, on August 8, 1918, in the great offensive being waged by the Allies at that time. It was exhibited for a time in a railway yard in Paris and later was taken to England. To the best of our knowledge this was the only mount carrying a gun of this caliber that was captured. The Belgian Army captured several 17-centimeter mounts and one 38-centimeter mount, and the Americans have two 17-centimeter one 21-centimeter, and one 24-centimeter mount. These mounts are illustrated on plates 385 to 399, 36, 55 and 56.

368. Gun.—The gun on the mount examined is a 40-caliber naval piece of model 1914 of 42 calibers total length. The tube is rifled with 80 grooves having a uniform twist to the right of 1 centimeter in 10 centimeters. The breechblock is of the ordinary Krupp sliding wedge type and is fitted with a mechanical firing mechanism. As with all other large guns having this type of breech, this gun uses semifixed ammunition.

369. Recoil Mechanism.—The recoil mechanism is of the hydro-pneumatic type and comprises one pneumatic recuperator cylinder mounted at the bottom of the cradle in the center and two hydraulic cylinders likewise mounted on the bottom of the cradle and on either side of the recuperator cylinder, plate 36.

370. Elevating Mechanism.—The elevating mechanism comprises two straight racks, plate 387, engaging with two pinions inclosed in floating housings and attached to one shaft. This shaft is connected by means of a worm, wheel, and shaft and on the right side of the gun with elevating handwheel shown near the elevation quadrant.. This is the only railway mount so far observed in any of the armies in which the attempt has been made to use this straight rack, which is much more easily machined than any of the usual curved elevating racks. On the under side of the floating housings two rollers are carried on which the back of the rack rides and which hold the rack in perfect mesh with the pinions. These two racks are attached by means of heavy pins to the rear of a cradle. The cradle trunnions are provided with the same roller type of anti-

friction device used on the 21-centimeter mount already described. The mechanism used on this mount is shown on plate 388. An elevation arc, plate 403, is attached to the cradle on the right side.

371. TRAVERSING MECHANISM.—See "Traversing Mechanism" for the 21-centimeter railway mount. The design of the car traversing mechanism over the rear truck is shown on plates 390 and 391, and the mechanism used in giving the mount all round traverse is shown on plates 392 to 395. The traverse rollers on the 21-centimeter mount are separate and exposed, while on this mount, plate 396, they are housed in and geared together.

372. GUN CARRIAGE.—The gun carriage is incorporated with the car body and is described in the next paragraph.

373. RAILWAY CAR BODY.—The gun is carried in a cradle of the design shown on plate 36. The cradle is provided with a heavy counterweight just above the trunnions to raise the center of gravity of the tipping parts sufficiently to permit of easy elevating and depressing. This cradle is suspended by means of its trunnions in cast-steel bearings mounted on the side girders of the car body. Each of the trunnions is provided with an antifriction device of the design shown on plate 388. The car body is built up of two single web structural-steel side girders connected by a series of structural-steel transoms and deck plates and the car platform is covered with light armor, plate 385. Both the traversing roller housings and center pivot trunnion bearings are bolted to the bottom of the side girders and serve to stiffen it. Jacking beams, which, in the case of the mount examined, had the jacks attached, plate 385, are carried under the forward and rear ends of the car body. The car traversing mechanism, a part of which forms the upper center plate over the rear truck, can be seen on plate 391.

374. ANCHORAGE.—See "Anchorage" for the 21-centimeter mount. The emplacement shown on plate 397 was used with batteries installed along the Belgian coast. This battery is only about 1 mile north of Ostend. The designs of the concrete and structural-steel platforms and the emplacing jacks are shown on plates 55, 56 and 398.

375. TRUCKS.—The two trucks on this mount, plate 385, are practically identical. The frame is of structural steel and each carries five axles with outside journals. The brakes are operated by hand only, and the end and center wheels are provided with two brake shoes each. Above each spring clip there is a capstan head screw, identical in design with those used on the 21 and 24 centimeter mounts, which is run down hard on the clip to relieve the springs of undue strains in firing from the track.

376. AMMUNITION SUPPLY SYSTEM.—The ammunition car captured with this mount is a wood box car of apparently standard design,

fitted with racks to carry 25 projectiles, plate 397. These projectiles are carried to the forward end of the car by means of an overhead trolley and are lifted through the roof of the car by means of a chain hoist on the end of the extension of the trolley track in the cab of the mount. It is carried forward by this second trolley, and placed on a tray attached to the breech of the gun, similar to those used with the 21 and 24 centimeter mounts. The projectile is rammed into the gun from this tray by hand. All of the projectiles in the car had an ogive of 10 calibers radius and all were fitted with false caps. The caps were placed on the projectiles as they were used. In the end of the cap there is a tapped hole through which a stick of wood is passed until it rests against the fuse. Considerable pressure is brought on this piece of wood when the small plug is screwed into the end of the cap. All of the projectiles captured were provided with time fuses of the 90-second clockwork variety.

377. Maintenance.—There are no apparent difficulties in the maintenance of this railway mount, all parts of which are very simple and substantially constructed. The elevating, traversing, and loading mechanisms had all seen considerable service, and yet no apparent difficulties had developed. The trucks had likewise apparently given no difficulty. It is not known just what difficulty may have been experienced with the recoil mechanism, but probably comparatively little.

378. Difficulties Involved in Service.—See same for the 21 and 24 centimeter mounts.

379. Merits.—See same for the 21 and 24 centimeter mounts.

380. Demerits.—See same for the 21 and 24 centimeter mounts.

PLATE 385

280-MM. GERMAN GUN ON RAILWAY MOUNT (RIGHT SIDE).

280-MM. GERMAN GUN ON RAILWAY MOUNT (LEFT SIDE).

PLATE 387

ELEVATING RACKS AND PINIONS OF THE 28·MM. GERMAN GUN.

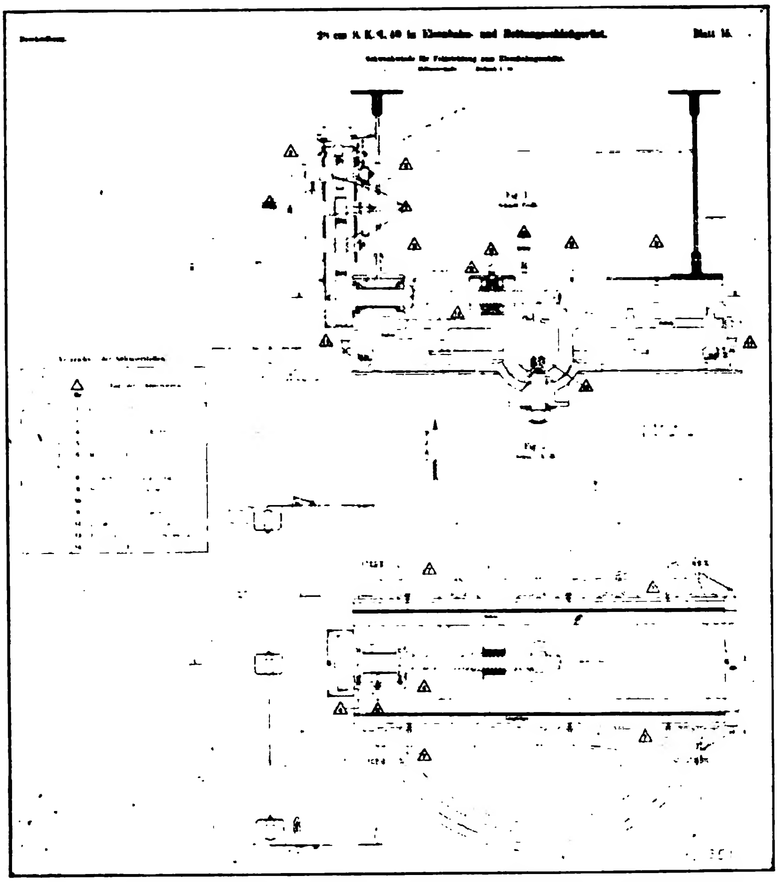
PLATE 388

ANTI-FRICTION BEARING OF THE 280-MM. GERMAN GUN MOUNT.

PLATE 389

ELEVATING ARC OF THE 280-MM. GERMAN GUN MOUNT.

PLATE 390



CAR TRAVERSING MECHANISM OF THE 280-MM. GERMAN GUN MOUNT.

PLATE 391

CAR TRAVERSING MECHANISM OF THE 280-MM. GERMAN GUN MOUNT (GEAR CASE ON LEFT SIDE OF MOUNT).

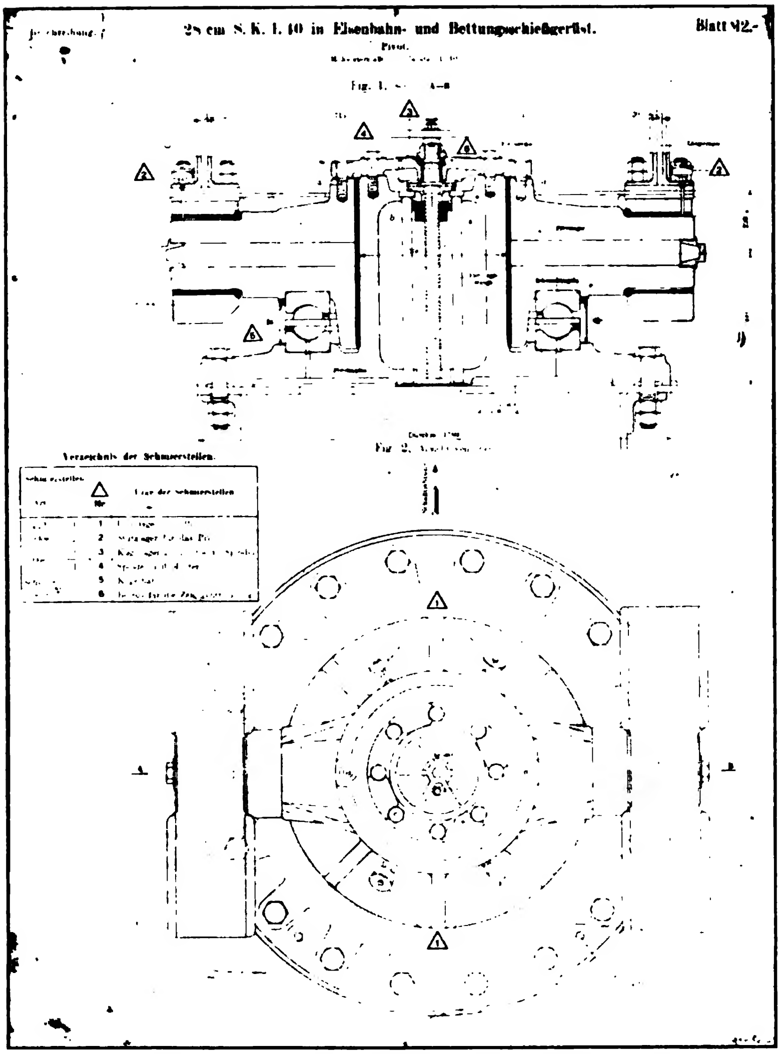
PLATE 392

CENTER PIVOT AND TRAVERSING MECHANISM OF THE 280-MM. GERMAN GUN MOUNT.

PLATE 388

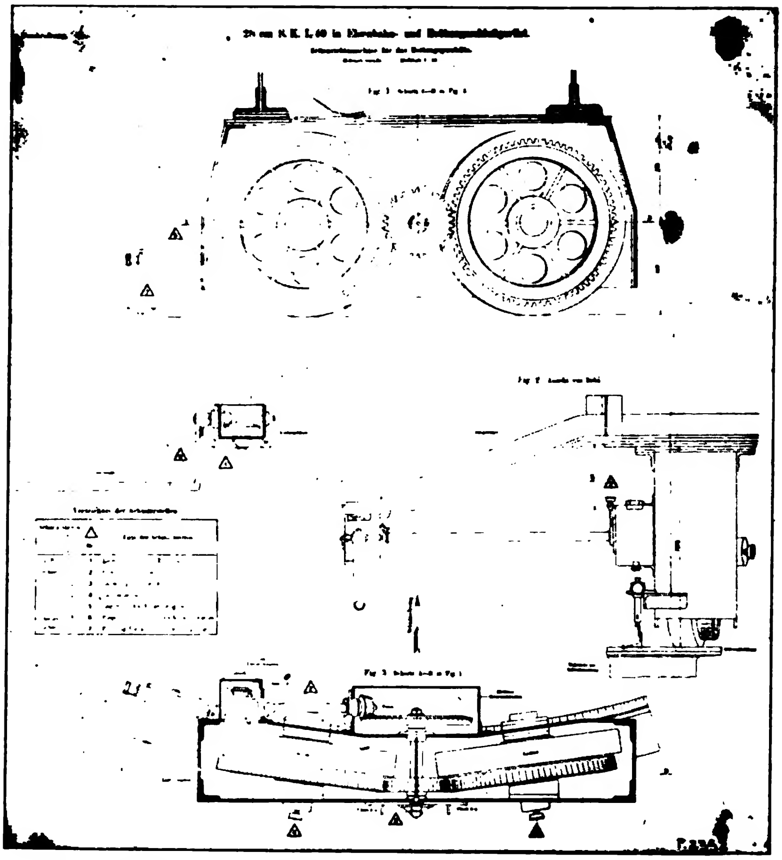
CENTER PIVOT OF THE 280-MM. GERMAN GUN MOUNT.

PLATE 394



CENTER PIVOT OF THE 280-MM. GERMAN GUN MOUNT.

PLATE 395



TRAVERSING MECHANISM OF THE 280-MM. GERMAN GUN MOUNT.

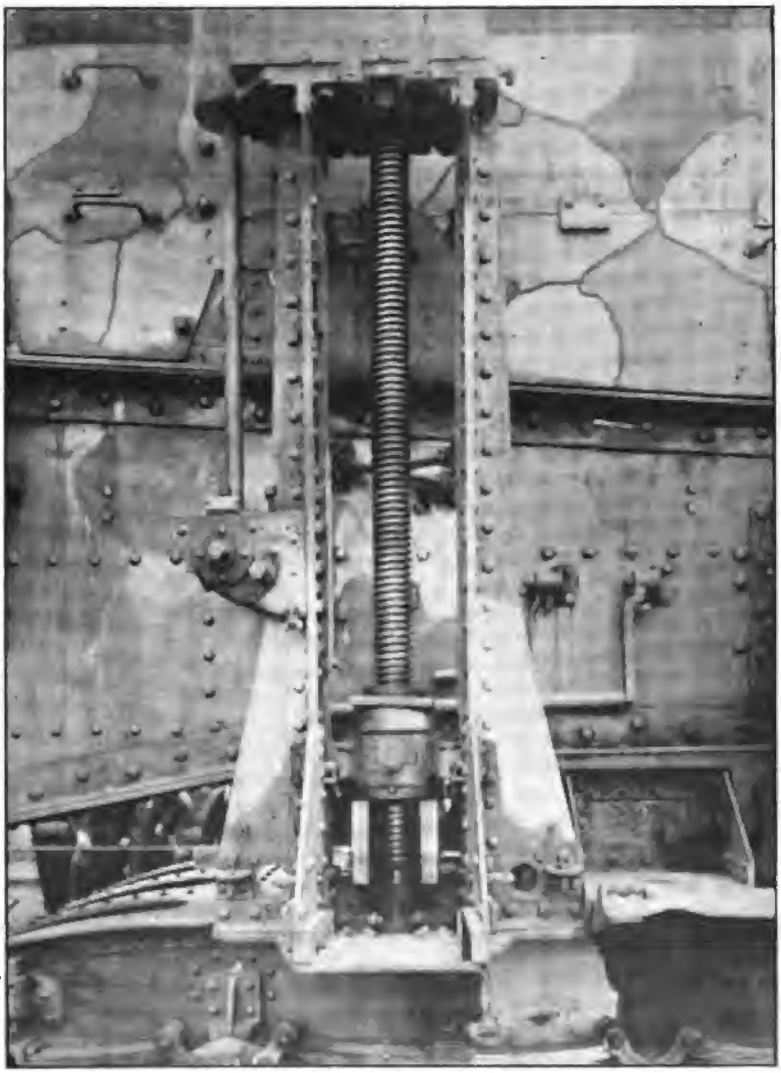
PLATE 396

PANORAMIC SIGHT OF THE 280-MM. GERMAN GUN MOUNT.

PLATE 397

CONCRETE EMPLACEMENTS FOR THE GERMAN 280-MM. GERMAN RAILWAY MOUNTS ON COAST OF BELGIUM.

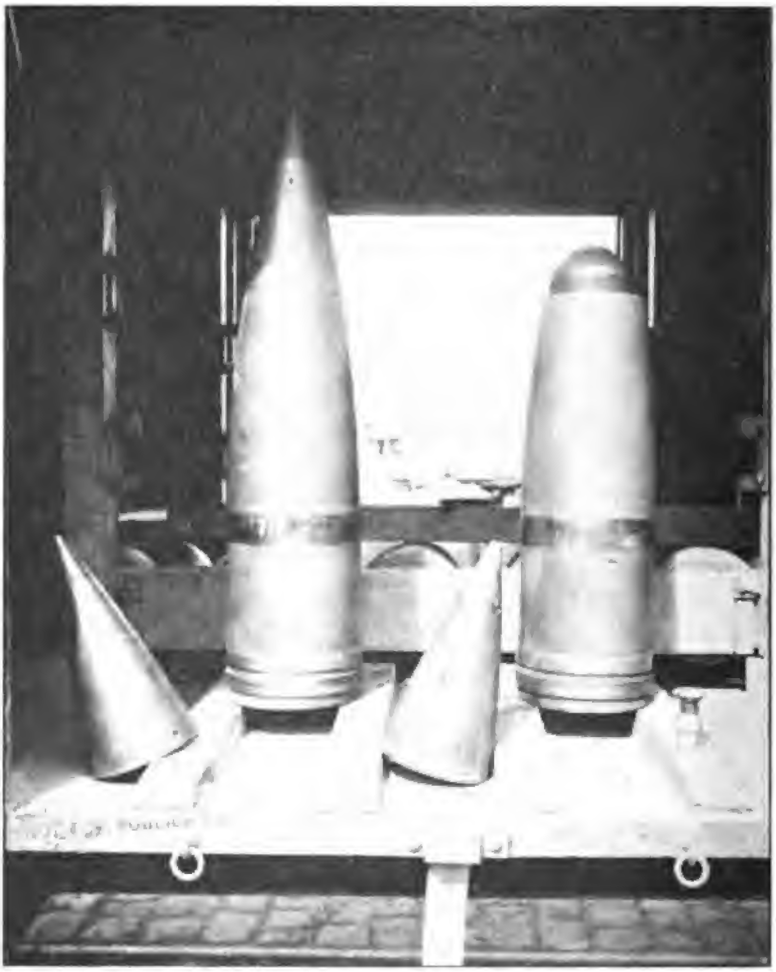
PLATE 398



EMPLACING JACK OF THE 280-MM. GERMAN GUN MOUNT.

181768—21——33

PLATE 399



PROJECTILES AND AMMUNITION CAR FOR THE 280-MM. GERMAN GUN MOUNT.

22.—GERMAN 380-MILLIMETER GUN ON RAILWAY MOUNT. (35)

381. This mount, plates 400 and 401, is of the cradle recoil type, firing from the wheels with limited traverse to an elevation of about 18 degrees, or from a structural-steel turntable type of ground platform with all round fire. The mount examined was captured by the Belgians and is in serviceable condition. Emplacements on which it could have been operated have been found in only two places, the one in the Forest of St. Gobain, west of Laon, and the other in the Bois de Chatelet, about 5 miles north of Chateau Thierry. All evidence available to-day indicates that while it was being operated from the emplacement in the Forest of St. Gobain it was serving as a mount for the long-range guns, all of which were made from worn-out 38-centimeter, 45-caliber naval guns. The mount bore the date of February, 1918, at which time it was probably completed by the firm of Krupp, and the evidence available to date indicates that it was the only mount of this design that they had. Gen. Arnoulde, Chief of Artillery of the Belgian Army, informed the writer that the mount had been found on a special track in the Bois de Leugenboom near the permanently emplaced 38-centimeter gun in that same woods, about 10 miles south of Ostend. There was no evidence that it had ever been operated from this position.

382. GUN.—The gun found on the carriage inspected was of the 1916 model and was number 33L. The total weight is 77,552 kilograms. The total length of the gun is 17.13 meters and the distance from the face of the breech block to the muzzle is 16.13 meters, making the gun about 42 calibers long. This is very significant, considering the fact that the gun is supposed to have a range of 55 kilometers (50,095 yards). The breech is of the standard Krupp sliding wedge type, the wedge being operated by one handle through a series of spur gears, to one screw.

383. Apparently the gun, plates 400 and 402, is built up of five main sections; the tube is reinforced by two hoops which are further reinforced by one jacket extending from the breech forward about two-thirds of the length, and a breech section attached to the last named jacket by the recoil lug. In the case observed, the tube has evidently lengthened to the extent of about 0.562 inches. The evidence of this is the extension of the tube beyond its original position with reference to the end of the forward hoop a distance of about 0.187 inches and the parting of the forward hoop from the hoop to the rear to the extent of 0.375 inches. This same condition was observed on several other guns of this design. The number of grooves is 100. The width of the grooves is approximately 0.219 inches, and the width of the lands 0.236 inches. The lands show slight signs of wear on the driving side and copper was visible both on

the lands and in the grooves at the muzzle of the gun, although not to such an extent as probably to have much effect. The diameter of the powder chamber is 42.5 centimeters. The recoil lug to which the two pistons of the hydraulic cylinders and the one piston of the recuperator cylinder are attached likewise serves to prevent rotation of the gun. It is forked at the bottom and bears on two sides of the recuperator cylinder which serves as a guide, plates 403 and 404. In this connection, it is significant that with every heavy German gun observed, rotation of the gun was prevented in this same manner, the breech lug having an extension which either bore on two sides of a recuperator cylinder or between two recuperator cylinders. It is certain that there were no cases of a spline on the gun sliding in a way in a cradle. In traveling, the gun is locked in battery by the very simple device shown on plate 402.

384. This gun is identical in design with the guns of the Battery Deutschland and the Battery Pommern, at Leugenboom, described in Appendix III. The guns of these batteries are accredited with a maximum range of 55 kilometers. In the report which was examined in Gen. Arnoulde's office, the range was given as 42 kilometers. There is no question but that the Battery Pommern fired on the city of Dunkirk, requiring a range of 45 kilometers. Whether the Battery Deutschland, which is 2 kilometers northeast of Ostend, likewise fired on Dunkirk is a question. The basis for the statement in the Bulletin de Reseignements de l'Artillerie of January-February, 1918, crediting these guns with a range of 55 kilometers is not known. Whether the provision for an elevation of 55 degrees has any real connection with the unusual range of a gun 42 calibers in length and credited with a muzzle velocity of 800 meters per second, is not known definitely. It seems certain, however, that the specification given the designers for a maximum elevation of 55 degrees resulted in the type of elevating mechanism described later.

385. Recoil Mechanism.—The recoil mechanism is composed of two recoil cylinders and one spring pneumatic recuperator cylinder, all located on the bottom of the cradle, plates 403 and 404. Each of the recoil cylinders is a separate cylinder carried in brackets cast on the cradle and each is provided with a buffer approximately 32 centimeters long. The filling plugs are on the ends of the buffers. The maximum length of recoil is 1.3 meters. This distance is, of course, approximate, and was arrived at after careful examination of all of the apparatus. In a report examined in the office of Lieut. Gen. Arnoulde at Brussels, the length of recoil was given as 1.15 meters. On inquiry, it was found that this was likewise an estimate. Two rods screwed to the recoil lug and extending to the rear, plate 403, carry a cross head to which the piston of the recuperator cylinder is

attached. The recuperator cylinder, plates 405 and 406, is likewise a separate cylinder carried in brackets cast on the cradle, and at the rear on both sides it is planed to serve as a guide for the recoil lug, to prevent rotation of the gun.

386. ELEVATING MECHANISM.—The elevating mechanism of this mount is unique in several respects. Provision is made for elevating the gun from 0 degrees, the loading angle, to 55 degrees. It is composed of two straight racks, plate 407, driven through pinions, a wormwheel, worm, a double speed transmission, sprockets and chains, by four two-man handles, plates 408 and 409. The straight racks slide in ways which are parallel to the inclined lower face of the forward end of the side girders. It was necessary to put them in this position to secure sufficient movement to elevate the gun to 55 degrees. At the lower end, they are connected with each other by a heavy shaft, plate 407, to which are attached the two connecting rods running up to the bottom of the cradle. It will be observed, plate 409, that provision is made for two handles on each side of the car, each for two men. A double speed transmission, similar in design to those used on the 21 and 24 centimeter mounts is incorporated in this mechanism. The ratio on the low gear is 4.125 turns of the handle for one degree of movement of the gun. One man can operate the elevating mechanism with some difficulty at low gear. It seems probable that eight men could operate the high gear without serious difficulty. The gun and cradle were identical with five others observed in the coast defenses of Belgium. On all of the other guns, however, the elevating mechanism included double telescoping screws. It is probable that this gun when used on a ship or in the coast defenses was likewise so elevated, and that it was impossible to accommodate this mechanism on a railway mount and secure the elevation desired. It is likely that under the specification of such an extreme elevation no other type of mechanism could have been adapted to this cradle and mount without serious difficulty. Judging from the diagram, plate 404, which was made up from measurements of the gun and cradle and the estimated length of recoil of 1.30 meters, it seems probable that the gun can be fired from the track, the mount operating as a rolling mount, to an elevation of 18 degrees, 30 minutes. If the length of recoil is 1.15 meters, as given in Gen. Arnoulde's report, it is probable that an elevation of as much as 20 degrees can be secured. The gun can be fired above 18 degrees only from a special emplacement.

387. TRAVERSING MECHANISM.—This mount is provided with a car traversing mechanism installed on the front span bolster, giving a maximum traverse of 1 degree on each side of center. This mechanism, which includes the usual screw, plate 411, is operated through a

series of spur gears and chains, plate 412. There seems a good reason for providing a high and low speed elevating mechanism, but just why the designers provided both high and low speed on this traversing mechanism is not known. In comparing this design with French and American designs, it is significant that no rollers are provided between the body of the mount and the span bolster. Cast-steel shoes narrowing down to a wedge are provided on each side, plate 426. The designers evidently preferred to count on an ample supply of man power rather than provide the usual rollers. A second traversing mechanism for all-round firing is installed in the emplacement, plates 419 and 420. In this case the racer of the emplacement rests and rotates on 112 8-inch steel balls. A complete circular traversing rack made up of angles and steel pins is bolted to the structural steel base, plate 419. A pinion carried on a vertical shaft on the side of the racer which corresponds to the rear of the carriage engages with this rack, and the mechanism is driven either from two 2-man handles on shafts carrying a worm engaging with a wormwheel on top of this vertical shaft or by means of four handles carried in gear cases on either side of the mount, plate 420. Motion is communicated to the vertical shaft from these four handles through two shafts carrying two universal joints each. These latter handles are apparently the ones ordinarily used, if one may judge from the scheme of operation shown on plate 422.

388. Gun Carriage.—The gun carriage is incorporated in the car body and will be described in the next paragraph.

389. Railway Car Body.—The cradle is a cylinder of simple design having ribs at long intervals and of a depth of only about 3 centimeters. Other cylinders observed for the same design of gun were without any ribs whatever. The walls of the cylinder have a minimum thickness of 10 centimeters and a maximum thickness of 13 centimeters over the ribs. The design of the antifriction mechanism is shown on plate 414. As shown on plate 411, a counterweight in two sections is attached to the top of the cradle. Both sections can be raised and locked together, or, if desired, the rear section raised and locked in place by the two tie-rods. The railway car body, plates 400, 413, 414, and 415, is made up of two single-web side girders connected in the front and rear by heavy structural-steel transoms and further reinforced in the front by the heavy cast-steel housings for the elevating mechanism. The trunnion bearings are of cast steel and are simply bolted to the top chord with single keys to the rear of them. These single keys have the positive backing of one top cover plate each. The face of the horizontal section of the lower chord of the side girders is planed and is provided with a key at each end, plate 416. Eight 2-inch holes are provided in each lower chord

at the front end and six at the rear. The purpose of the hooks shown on the front is not known.

390. The designers avoided the use of sharply curved angles, plate 415. There are only two slight curves on the angles of the lower chord. The working platforms provided on each side to the rear of the trunnion seat are locked in their traveling positions, as shown on plate 425.

391. ANCHORAGE.—The gun can be fired to a maximum elevation of 18 degrees 30 minutes with the mount operating as a rolling mount. Above this elevation the trucks must be removed and the mount is operated from a fixed emplacement.

392. In August, 1918, when the German Army had retired from the salient between Soissons and Rheims, the emplacement shown on plates 417 and 418 was found in the Bois de Chatelet. All evidence indicated that this emplacement had not been used in this position. It was simply in process of erection when it was abandoned. The Germans attempted to destroy it, but succeeded only in ripping loose a few plates. At the time that this emplacement was captured, no descriptions of any kind were available of the carriage for which it was intended. The writer's failure to find any emplacement in Belgium from which the mount could be operated led to a search for emplacements in France, and an examination of the emplacement shown revealed the fact that it was the one sought.

393. The mount is run in on the emplacement in a position shown approximately on plate 417. It is then raised by four jacks, one of which can be seen in the left foreground on plate 419, and the trucks removed. The rotating section of the emplacement is then turned 90 degrees, and the carriage lowered onto the side girders. In the right center of plate 417 is shown one of the key plates, which corresponds to a similar plate on the bottom chord of the carriage girders, plate 426. The six bolt holes shown in the key plate on plate 418 correspond to the six holes in the lower chord on plate 426. On this plate only the bolt holes on the outside of the girder web are visible. From the fact that the key plates for the forward end must have eight bolt holes and those for the rear six, it is evident that the traversing mechanism is located on the part of the emplacement corresponding to the rear of the carriage.

394. It is necessary to install two auxiliary construction tracks on either side and parallel to the approach track for the service of the Gantry crane used in installing the emplacement. One of these tracks is shown on plates 417 and 418 and both are shown in both elevation and plan on plates 419 and 420. The emplacement, as well as the Gantry crane used in the work of installation, are shown on plate 421. German handbooks allow a period of three weeks for the

installation of the structural-steel emplacement. The mount is shown completely installed and in operation on plate 422. This plate is made from a cut contained in a printed publication of the Krupp Co., which manufactured the mount.

395. CAMOUFLAGE.—In the case of the emplacement found in the Bois de Chatelet, sockets were placed in the center of the approach track at intervals of about 30 feet, into which trees with trunks up to about 6 inches could be placed for the purpose of concealing these tracks.

396. TRUCKS.—All of the trucks, as well as the span bolsters, are constructed entirely of structural steel, plate 401. The front trucks contain five axles each and the rear trucks four axles each. The journals are approximately 14 centimeters in diameter by 32 centimeters in length, and the wheels are 95 centimeters in diameter. On the front trucks, three wheels have two brake shoes each. On the rear trucks, the end wheels have two shoes each and the inner wheels one shoe each. The braking is done by hand only. A portion of the circular track on which rubbing plates attached to the span bolster on each side bear, can be seen on the front truck, plate 400. There are no rollers on any of the trucks or bolsters. The axles are equalized in pairs only, the center axles of the front trucks having no connection with the others, plate 423. The various dimensions of the trucks are given on plate 401.

397. AMMUNITION SUPPLY SYSTEM.—The provision made for supplying ammunition when the mount is operated on the emplacement is shown on plate 424. This narrow-gauge ammunition track can be seen likewise around the pit on plate 422. The indications are, from plate 422, that the track formed a loop around the pit in this case and that it was not a complete circle with turntable as was found in other emplacements in Belgium. A removable plate can be seen between the shot truck rails on the operating platform of the mount, plate 425. Over this plate is a light bridge, in the center of which is seen a ball on the end of the cable used in hoisting projectiles through the hole in the floor. The cable (0.5-inch) runs over a series of pulleys to a small drum in the box on the top of the left-side girder.

398. The ammunition is supplied from the storehouse over the narrow-gauge track already mentioned, the portion of the track around the pit being under the opening in the working platform. The projectile is raised by means of tongs attached to the hook under the ball and when at the top of the bridge the shot truck is run forward and the projectile placed on it. The shot truck inspected has no buffers, but four holes can be seen in the flange on the front which may have been provided for the attaching of a pad of some sort. The clear space over which the men could get up speed with the truck is about 5 meters. The gun is loaded at 0 degree ele-

vation. It is understood that the projectiles of the 38-centimeter gun of the same design at Leugenboom were rammed by 12 men. It is probable that the same number of men were used on the railway mount.

399. When the mount is operated as a rolling mount, the ammunition is supplied directly from the ammunition car. This necessitates the use of the extension to the car body, which extension, by the way, gives one the impression of having been an afterthought. This extension is pinned to the rear of the car body and is likewise connected by means of the two tie rods shown on plate 426. These tie rods do not seem absolutely necessary since the weight of the extension is carried by the rear truck. When the shot truck is at the end of the extension, the projectile can be placed upon it from the trolley that extends a short distance from the end of the ammunition car. When operated as an emplacement mount the extension of the car body was removed.

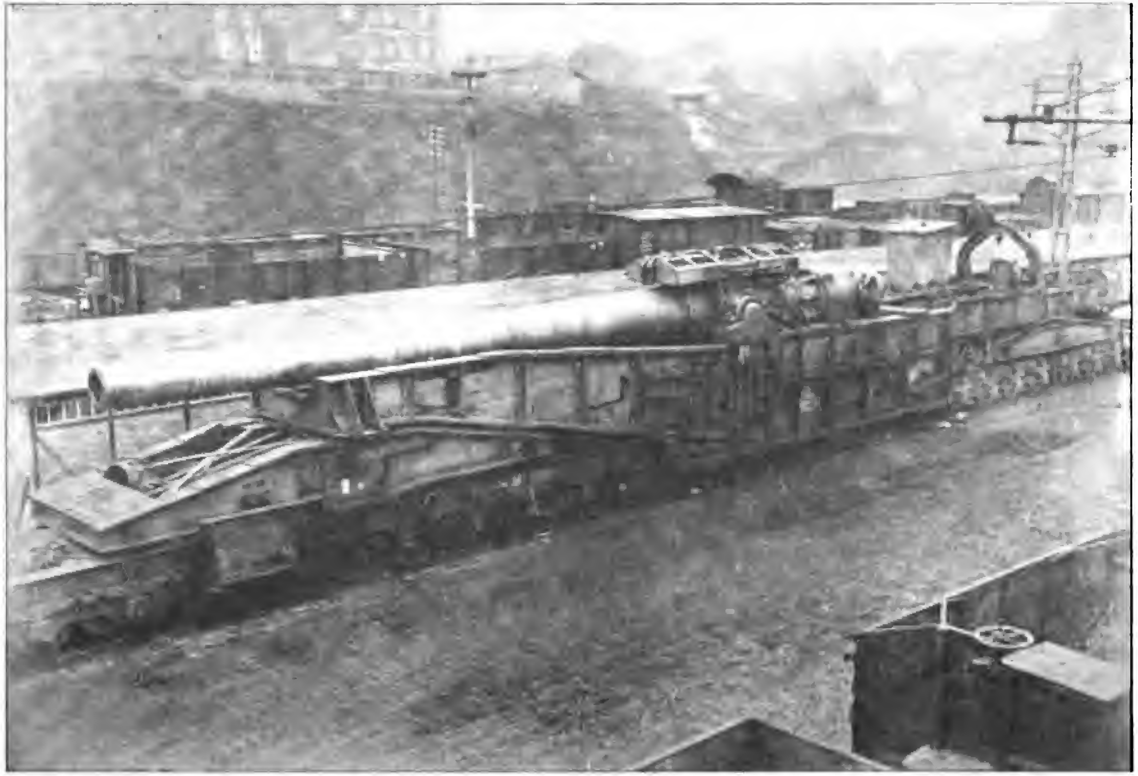
400. MAINTENANCE.—There seems to be no evidence that this mount involved any difficult problems of maintenance. The design is simple throughout and quite sturdy. It is not known how much difficulty they may have had in maintaining the desired air pressure in their recuperator cylinder. It will be observed on plate 413 that a small pump is provided on the left side of the mount, which presumably was provided for charging the recuperator. A gauge at the rear of the recuperator cylinder gave evidence of the existence of a floating piston. The gauge on the top of the cradle, plate 402, is capable of registering a pressure of 250 kilograms per square centimeter. If the pressure maintained in the recuperator was even half the pressure which the gauge was capable of registering, it is possible that they may have had some difficulty in maintaining their recuperator.

401. DIFFICULTIES INVOLVED IN SERVICE.—The mount is operated above 18 degrees 30 minutes from an emplacement of the type shown on plates 417 and 418. Any such contrivance as this is considered a decided nuisance and would not be tolerated in our own designs; neither would it be tolerated by any of our allies. It is significant that in German handbooks the time allowed for installing gun emplacements is usually from three to five times as great as that permitted in the American Army. It is probable that the full three weeks allowed was required for the installation of this emplacement. No other difficulties are apparent in the service of this mount

402. MERITS.—The simple design of cradle, generally simple design of the mount throughout, convenient ammunition supply system and high elevation, may be classed as merits.

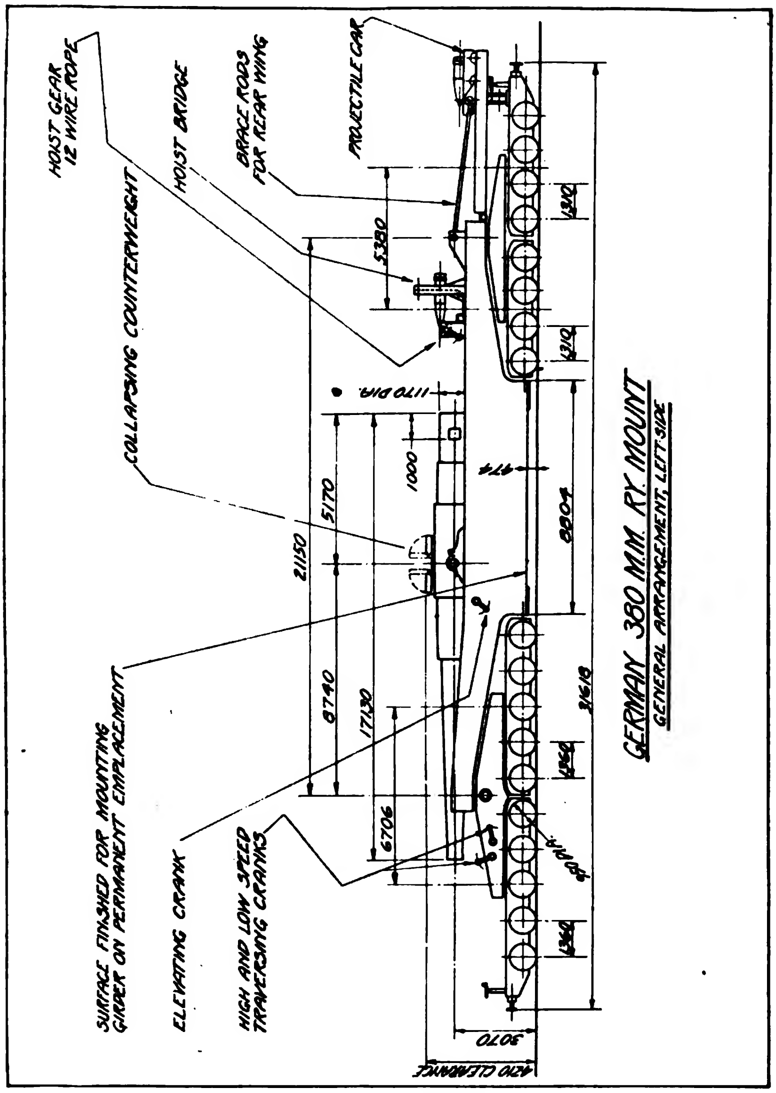
403. DEMERIT.—The necessity for the use of an emplacement of this type for the operation of the mount at high angles is a decided demerit.

PLATE 400



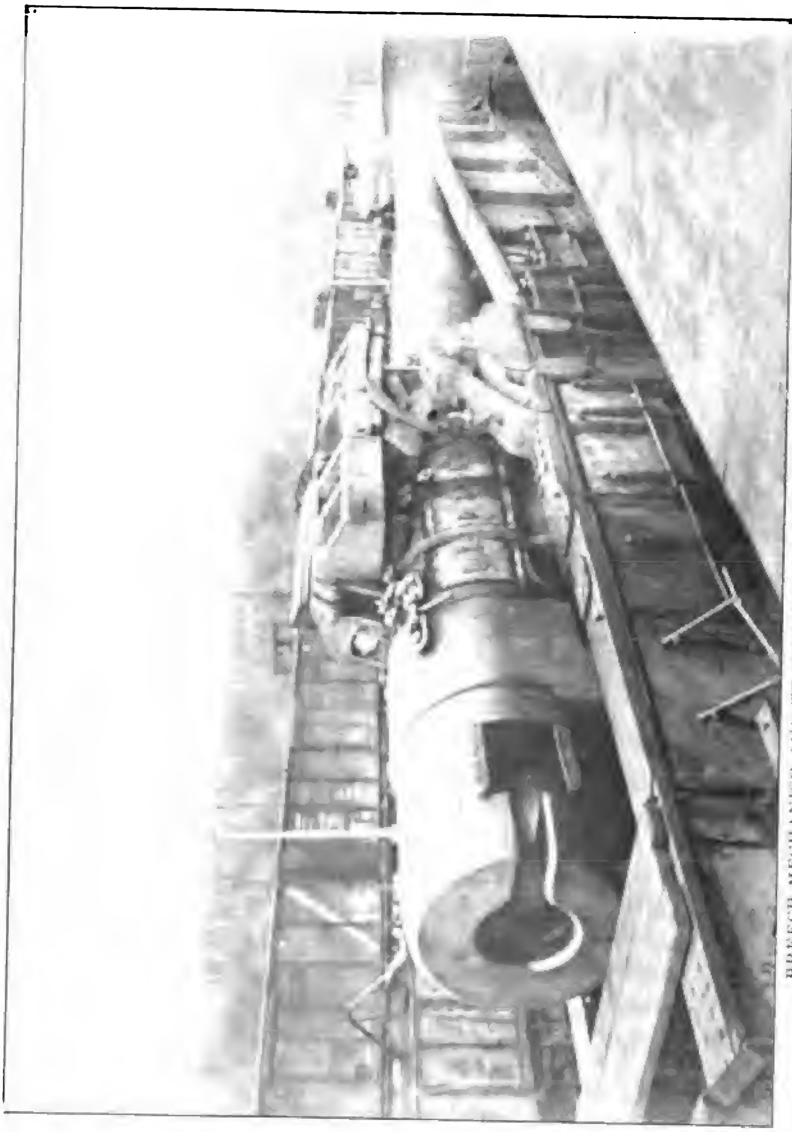
380-MM. GERMAN GUN ON RAILWAY MOUNT.

PLATE 401



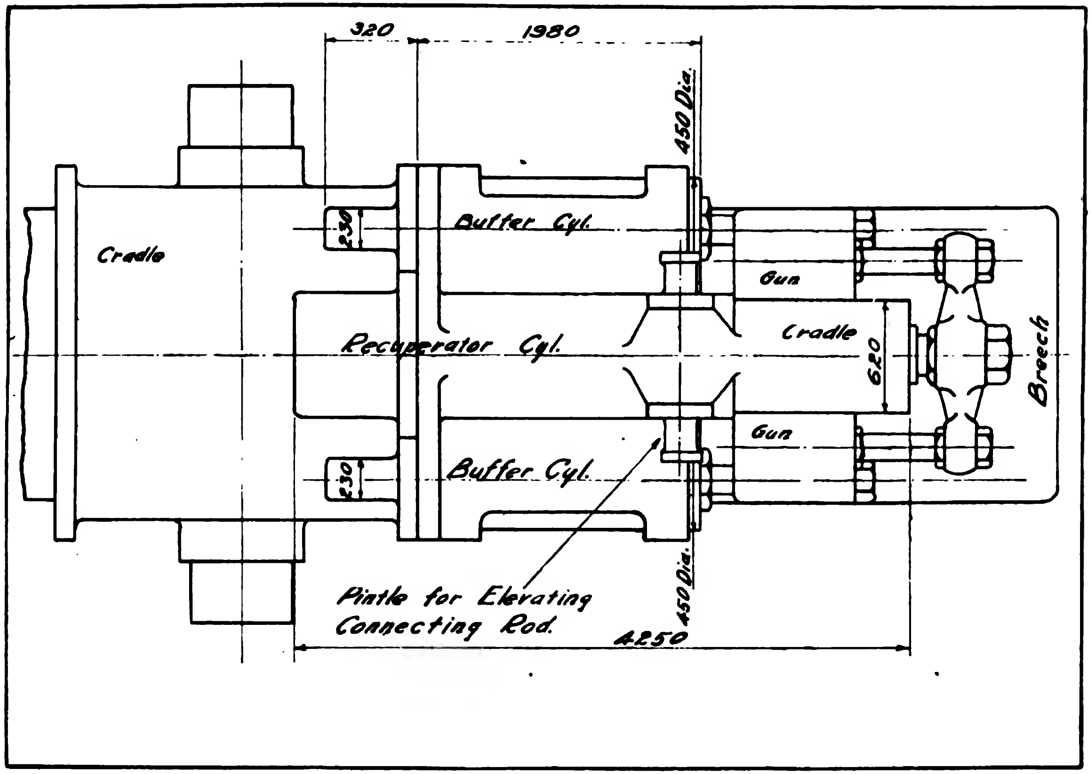
GERMAN 380 M.M. RY. MOUNT
GENERAL ARRANGEMENT, LEFT SIDE

PLATE 402



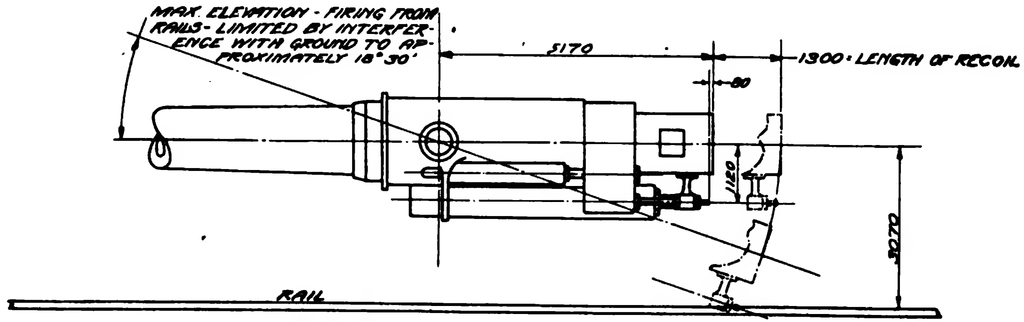
BREECH MECHANISM AND TRAVELING LOCK OF 380-MM. GERMAN GUN MOUNT.

Plate 403



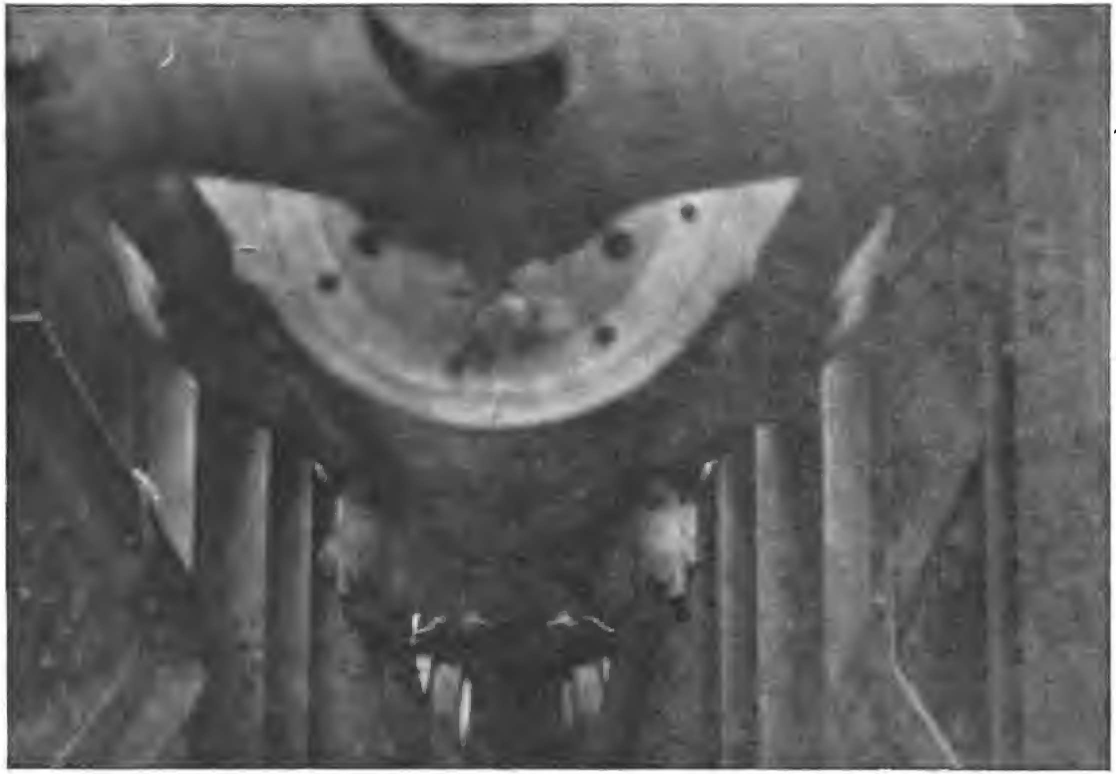
GERMAN 380-MM. RAILWAY MOUNT. RECOIL AND RECUPERATOR MECHANISM-BOTTOM PLAN.

PLATE 404



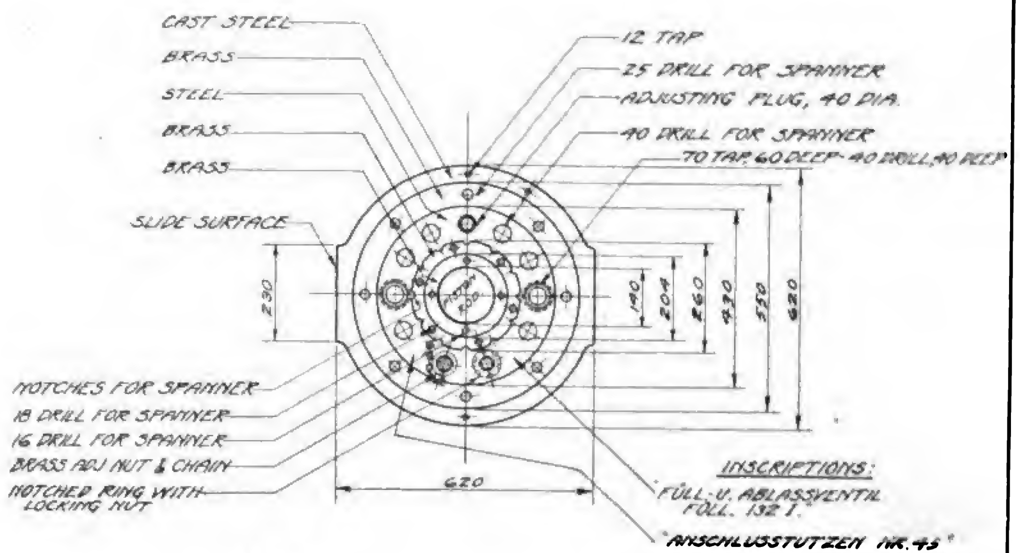
GERMAN 380 M.M. R.R. MT.
DIAGRAM - MAX. ELEV. - FIRING FROM RAILS

PLATE 405



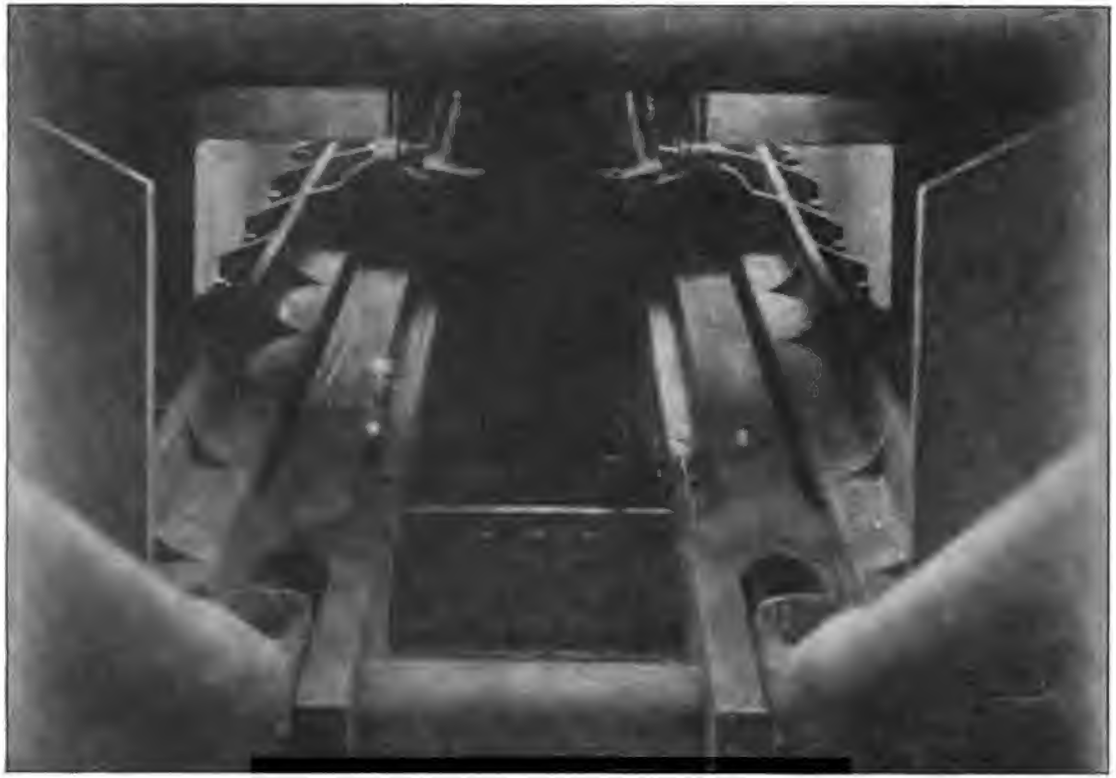
RECUPERATOR CYLINDER OF THE 380-MM. GERMAN GUN MOUNT.

PLATE 406



GERMAN 380 M.M. R.R. MT.
RECUPERATOR CYLINDER HEAD

PLATE 407



ELEVATING RACKS OF THE 380-MM. GERMAN GUN MOUNT.

PLATE 408

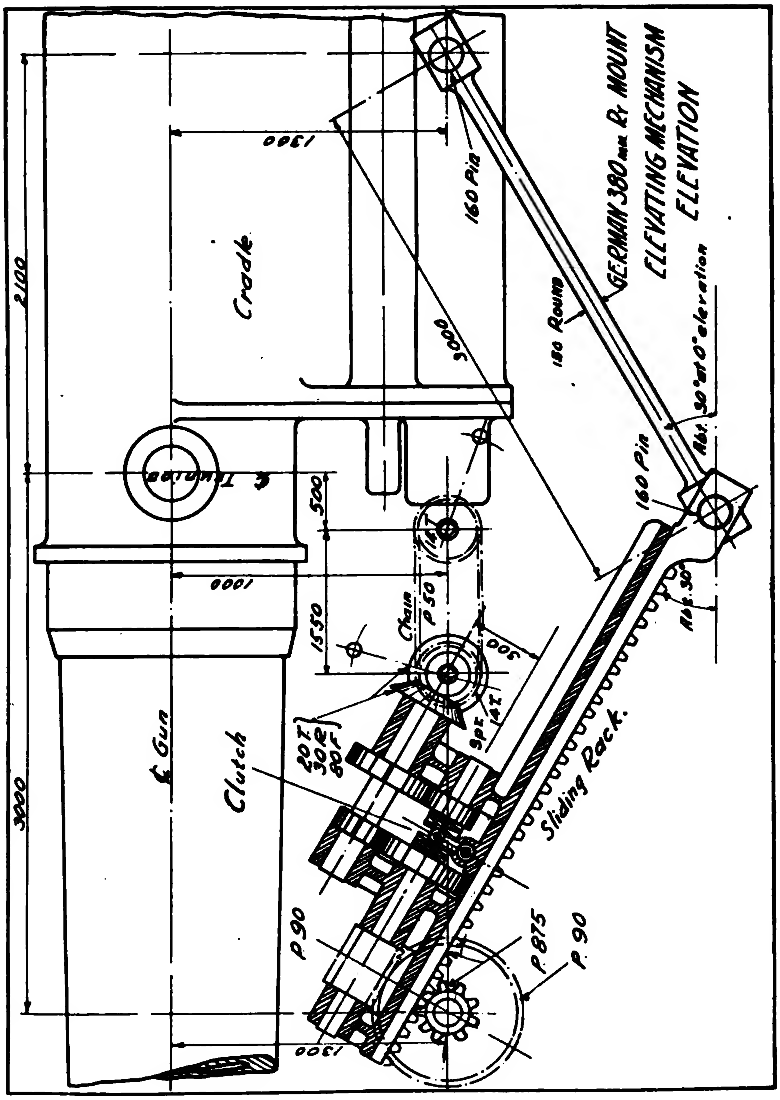

GERMAN 380 mm Ry MOUNT
ELEVATING MECHANISM
ELEVATION
Cradle
Clutch
Sliding Rack.
Chain
160 Pin
160 Pin
180 Round
Abt. 30° at 0° elevation
1300
2100
3000
3000
1000
500
1550
500
1300
P.50
P.90
P.875
P.90
20 T.
30 R.
80 F.

Plate 409

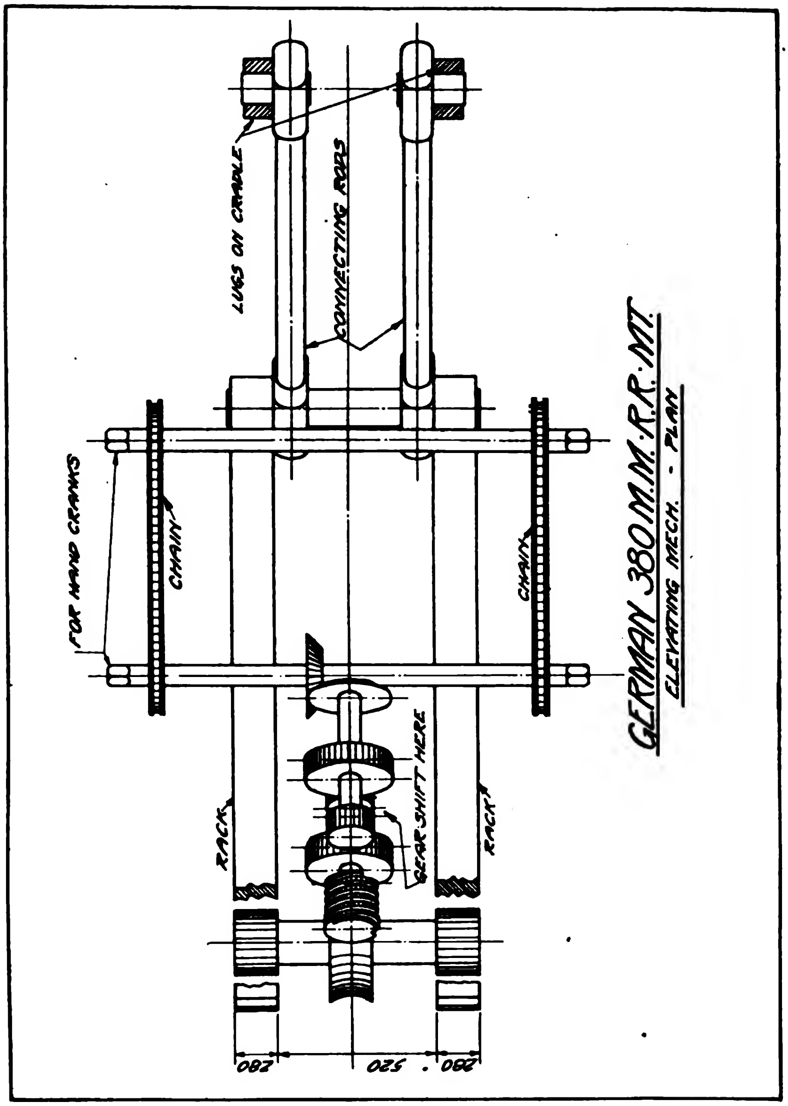
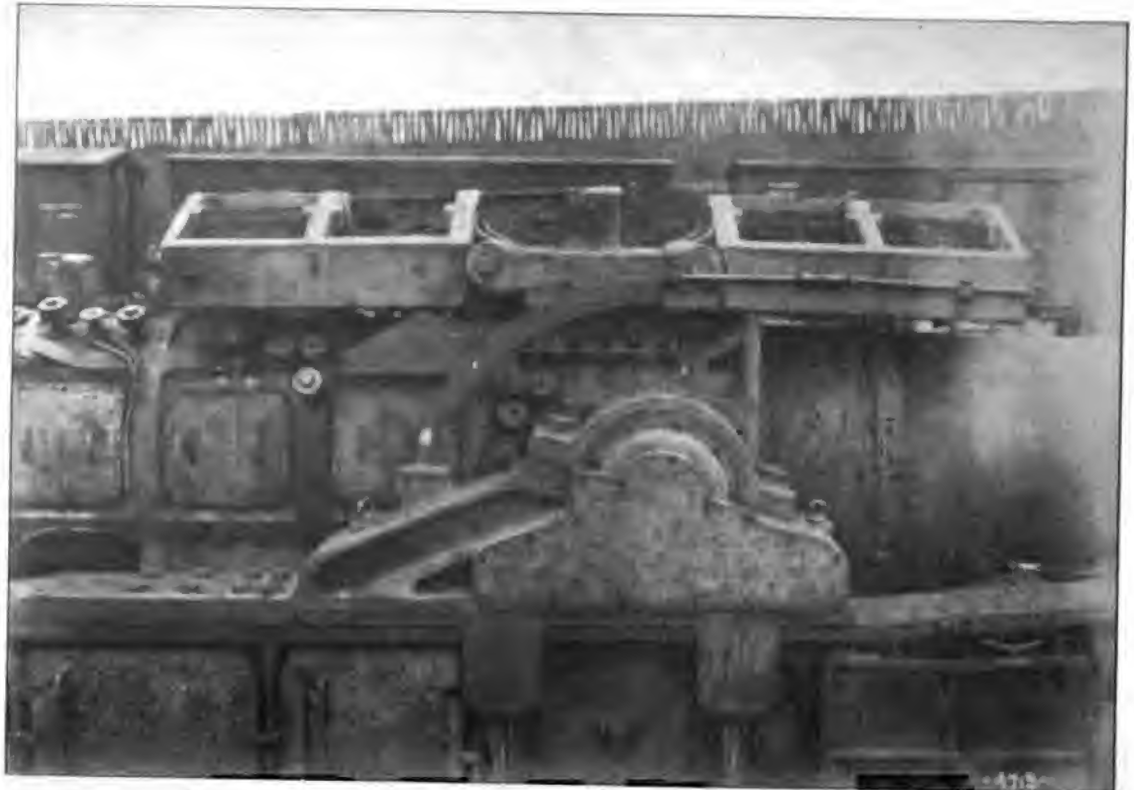
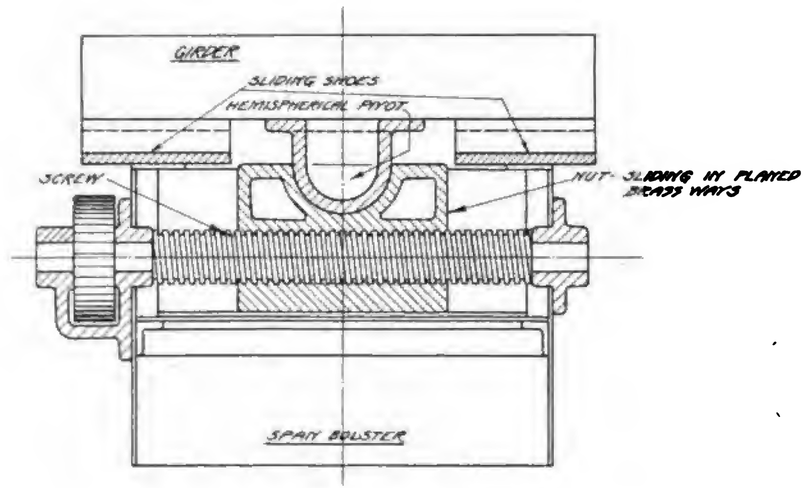

GERMAN 380 M.M. R.R. MT.
ELEVATING MECH. - PLAN
LUGS ON CRADLE
CONNECTING RODS
FOR HAND CRANKS
CHAIN
CHAIN
RACK
RACK
GEAR SHIFT HERE
280
520
280

Plate 410



COUNTERWEIGHT AND ELEVATION ARC OF THE 380-MM. GERMAN GUN MOUNT.

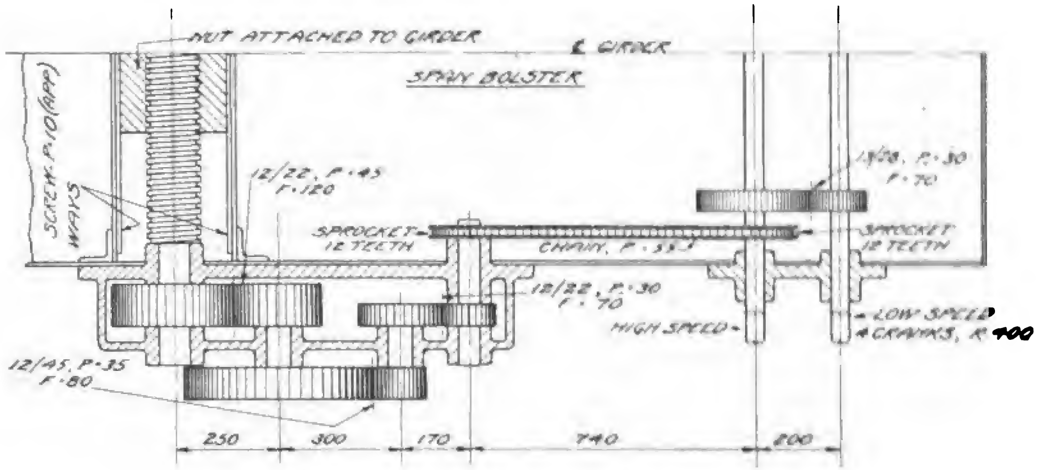
PLATE 411



GERMAN 380 M.M. R.R. MT.

TRAVERSING MECH.- LATERAL SECT. THRU TRAV. SCREW BEARINGS

PLATE 412



ONE TURN HIGH SPEED CRANK GIVES TRAVERSE OF
ONE TURN LOW SPEED CRANK GIVES TRAVERSE OF

GERMAN 380 M.M. R.R. MT.

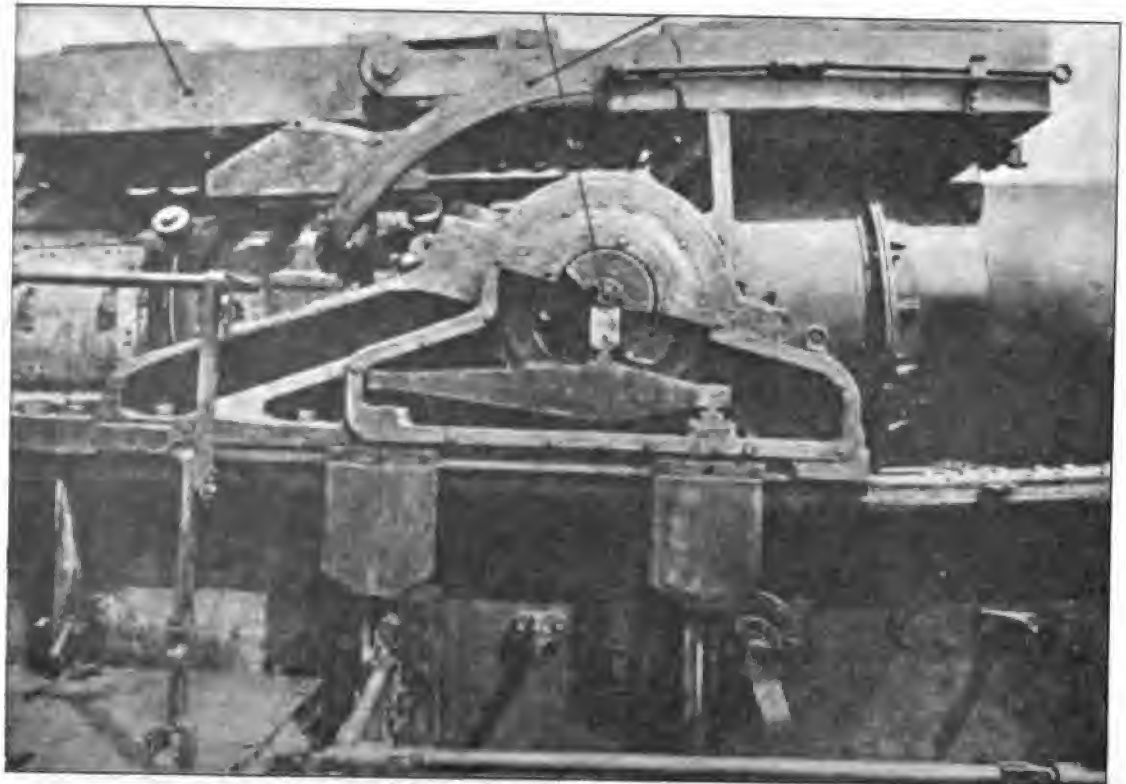
TRAVERSING MECH.-PLAN-SECTION THRU GEAR BEARINGS

NOTE: IN GEAR NOTATIONS, THE FRACTIONS GIVE Nº TEETH, P=CIRC. PITCH, F=FACE

Plate 413

PANORAMIC SIGHT OF THE 380-MM. GERMAN GUN MOUNT.

PLATE 414

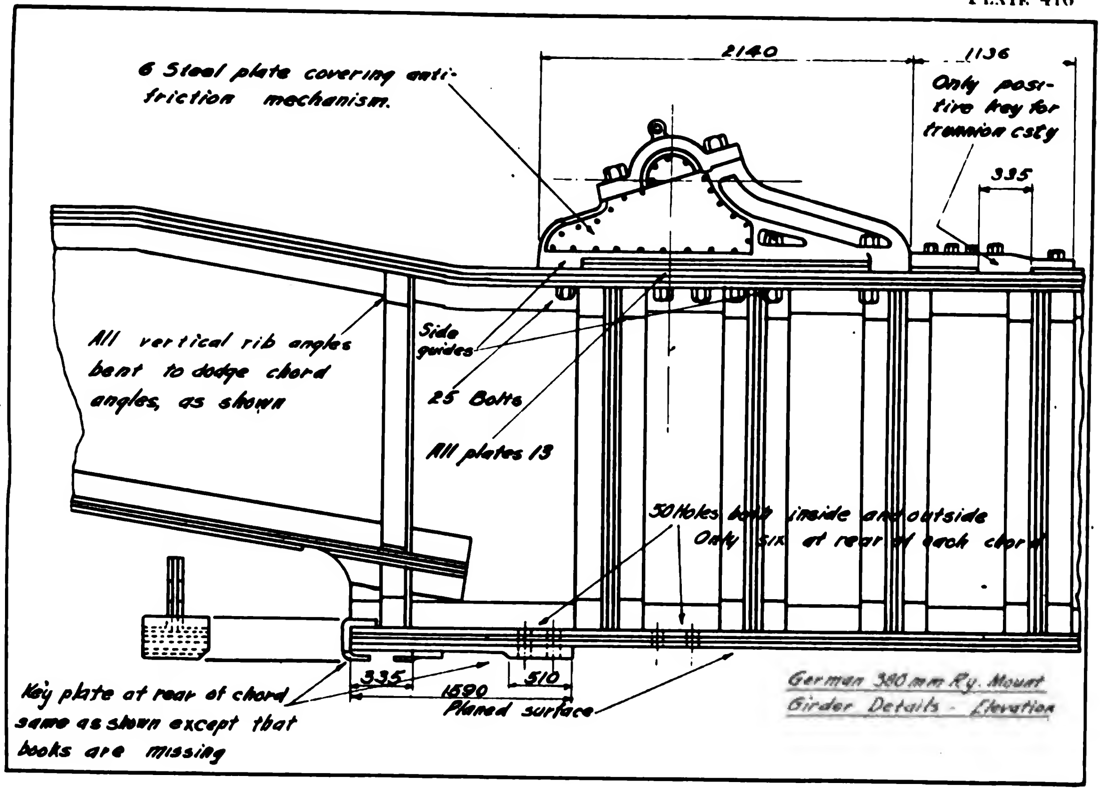


ANTI-FRICTION BEARING OF THE 380-MM. GERMAN GUN MOUNT.

PLATE 415

CAR BODY DESIGN OF THE 380-MM. GERMAN GUN MOUNT.

PLATE 418



German 380 mm Ry. Mount Girder Details - Elevation

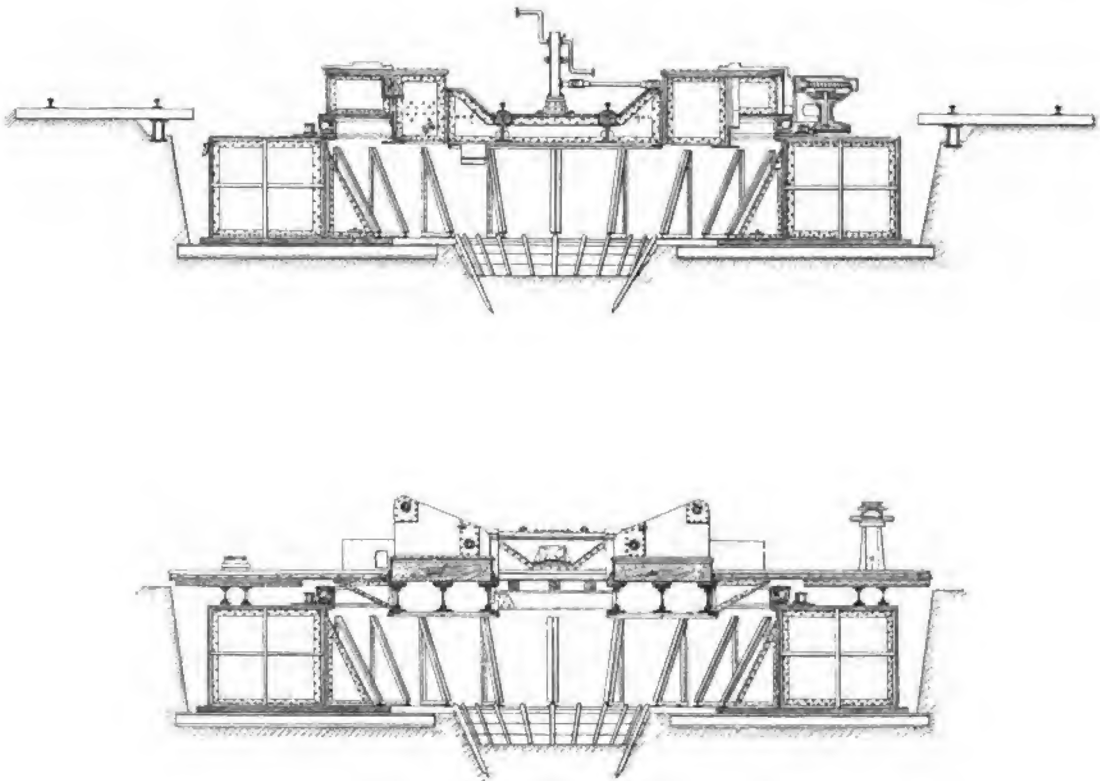
PLATE 417

EMPLACEMENT FOR THE 380-MM. GERMAN GUN MOUNT.

PLATE 418

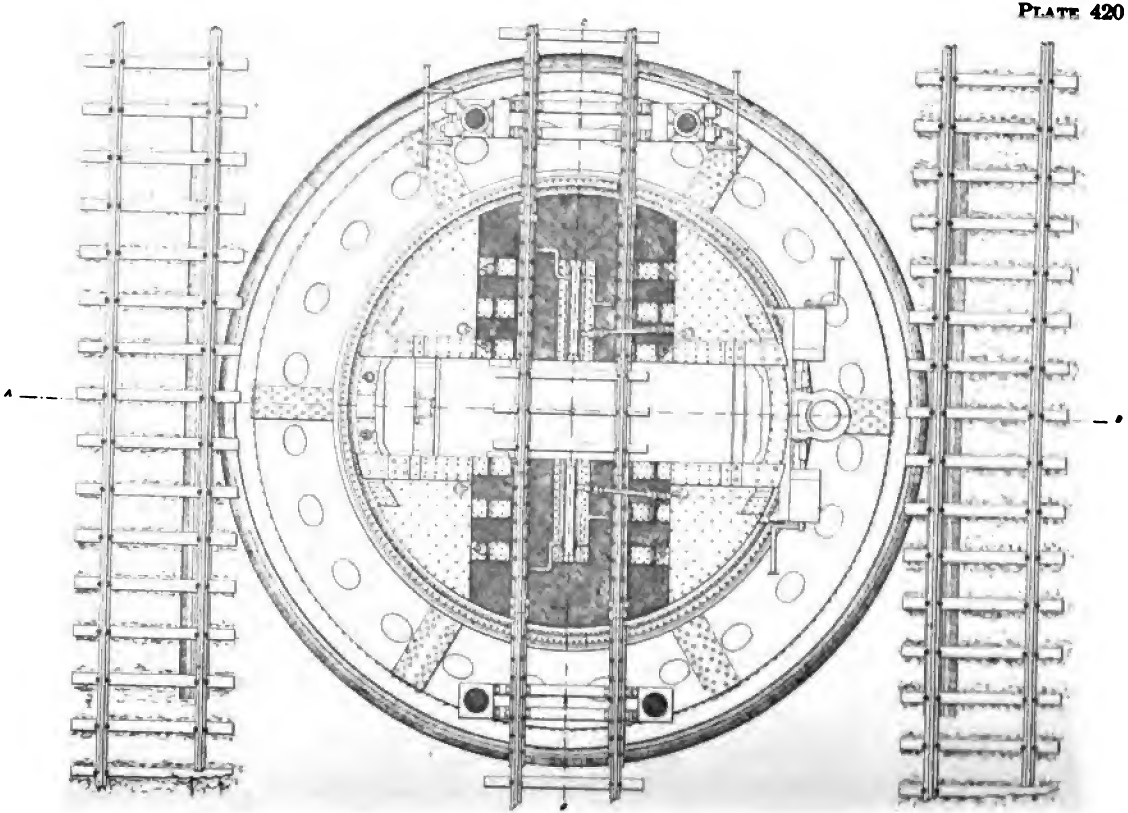
EMPLACEMENT FOR THE 380-MM. GERMAN GUN MOUNT.

PLATE 419



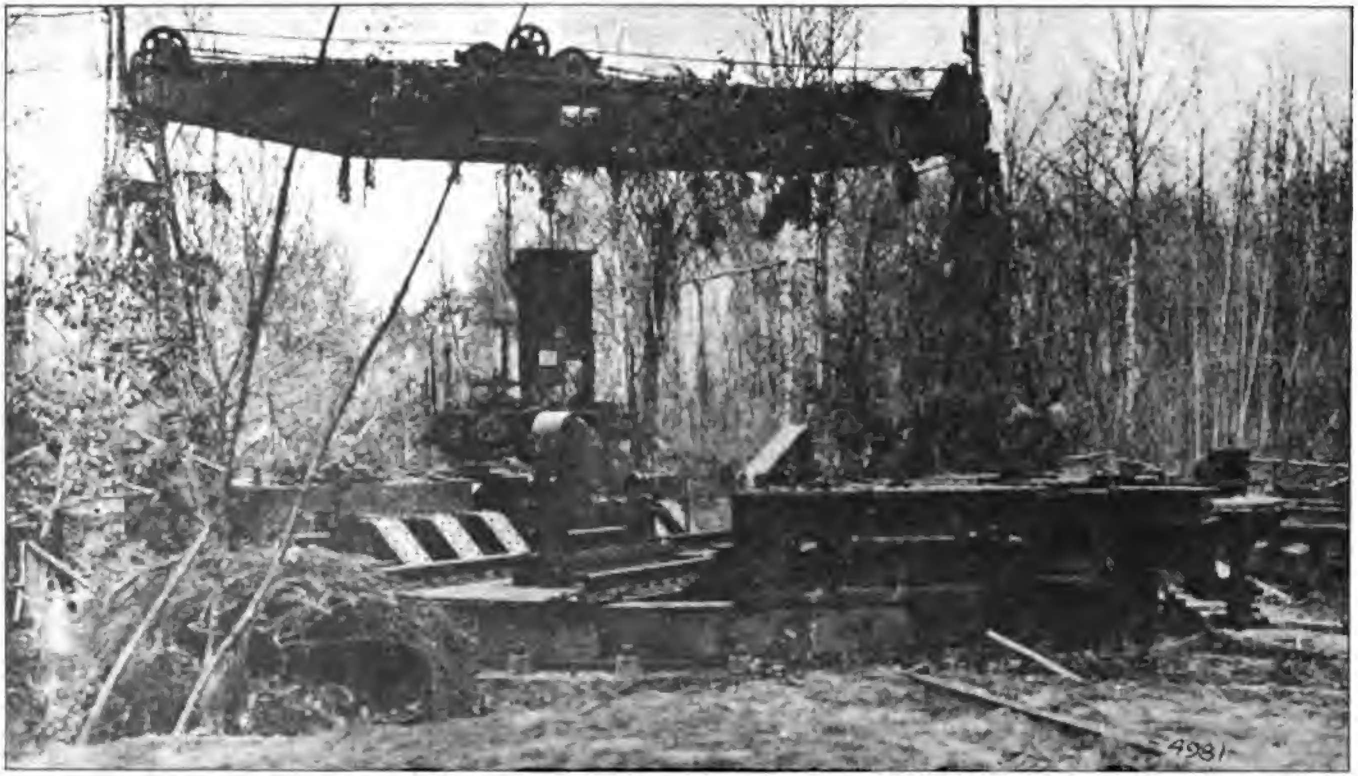
DESIGN OF EMPLACEMENT OF THE 380-MM. GERMAN GUN MOUNT (ELEVATION).

PLATE 420



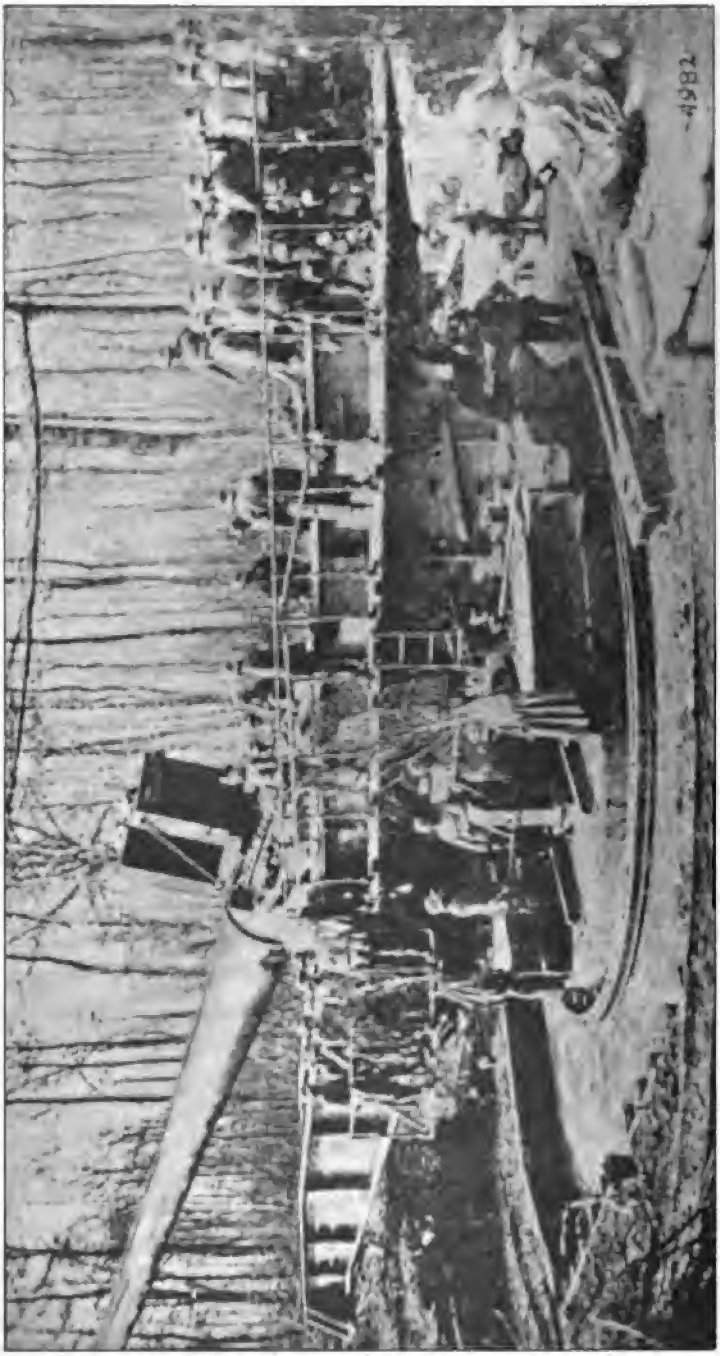
Plateforme metallique (en rognte pour materiel ennemi à grande puissance.

DESIGN OF EMPLACEMENT FOR THE 380-MM. GERMAN GUN.



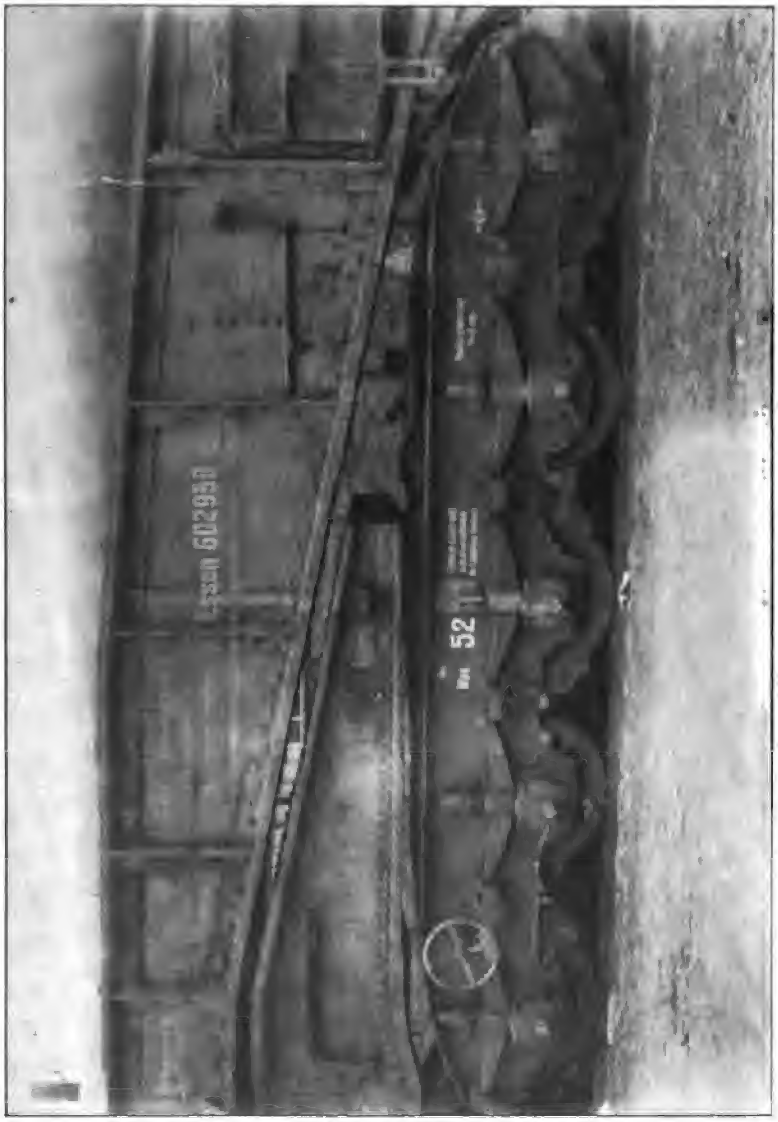
GANTRY CRANE USED IN INSTALLING EMPLACEMENT FOR 380-MM. GERMAN GUN MOUNT.

PLATE 422



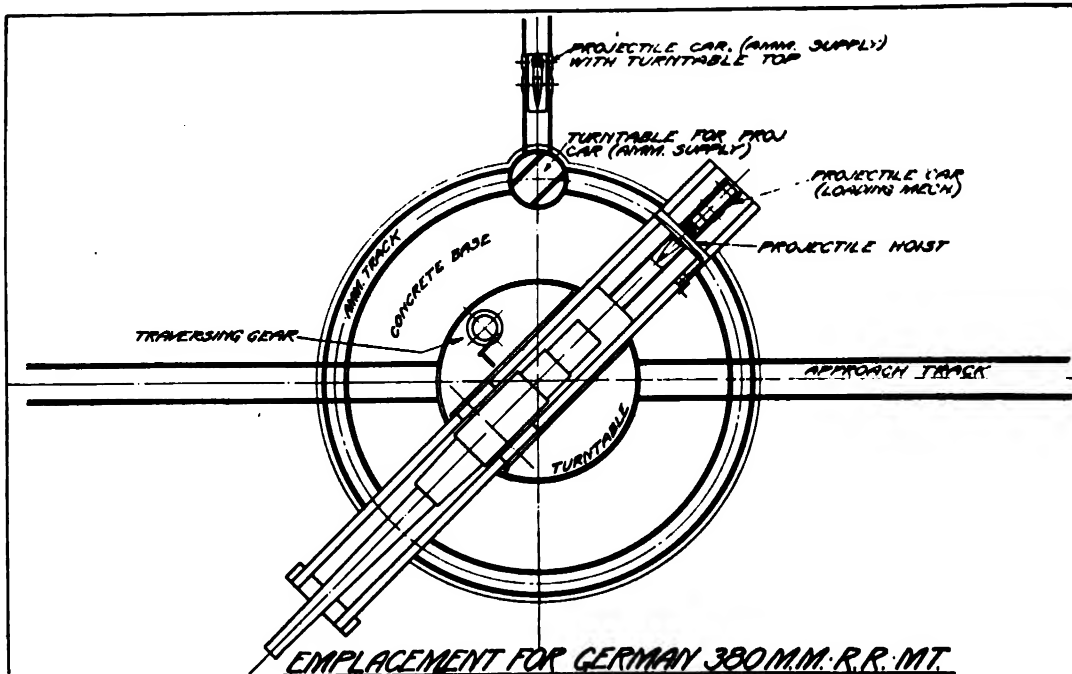
380-MM. GERMAN GUN MOUNT IN SERVICE.

PLATE 423



FRONT TRUCK OF 380-MM. GERMAN GUN MOUNT.

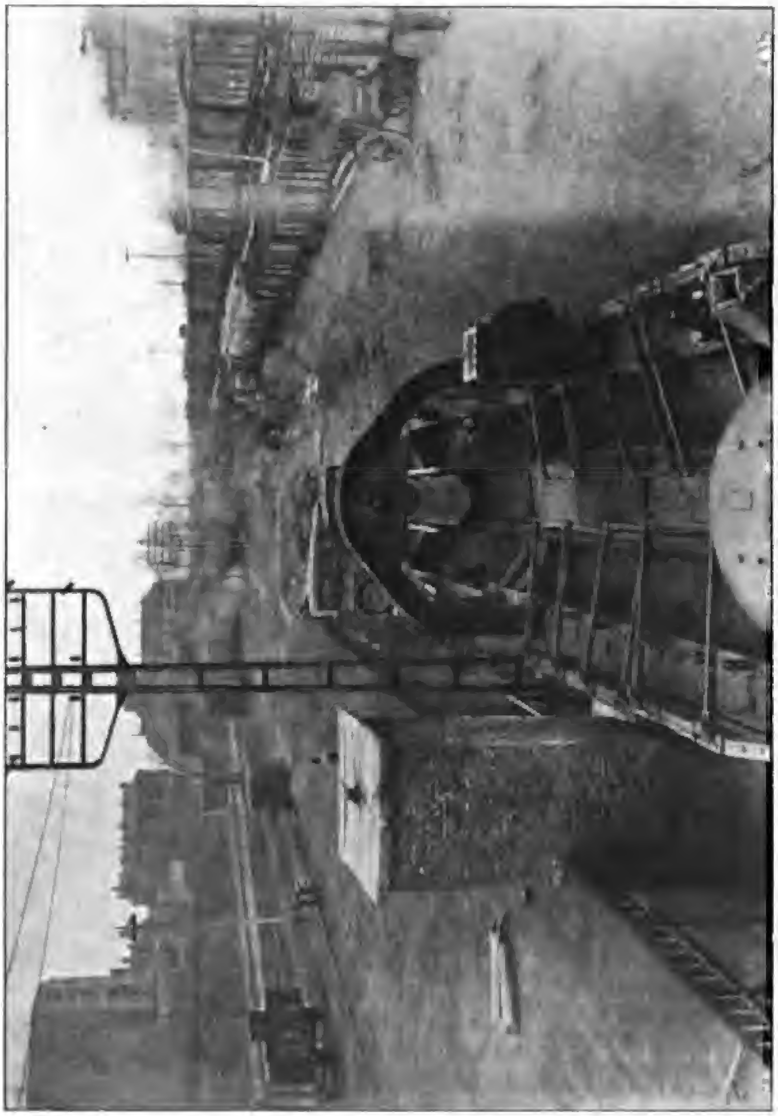
Plate 424



EMPLACEMENT FOR GERMAN 380 M.M. R.R. MT.

PLAN - SHOWING AMMUNITION SUPPLY SYSTEM

PLATE 425



OPERATING PLATFORM, SHOT TRUCK, AND AMMUNITION HOIST OF THE 380-MM. GERMAN GUN MOUNT.

PLATE 426

CAR BODY EXTENSION AND REAR TRUCK DESIGN OF THE 380-MM. GERMAN GUN MOUNT.

SECTION 4.

PRACTICAL QUALIFICATIONS OF RAILWAY ARTILLERY FOR LAND WARFARE AND COAST DEFENSES.

404. To arrive at a proper conclusion with reference to the qualifications desirable in railway artillery, the relative merits of various details of design, as brought out in sections 1 and 3, will be considered first. Next, the various services required of the pieces will be given as discussed in section 2, and the general characteristics necessary in a mount to satisfy each service will be determined. Finally, on the basis of the above discussions, the best combination of design details to satisfy the requirements of each mount will be recommended.

RELATIVE MERITS OF DESIGN DETAILS.

405. Design details will be considered under the same headings used in describing them in section 3. In addition, attention will be given to special requirements for coast defense.

406. GUN.—Practically all of the guns used on railway mounts are of old or obsolete design. None of the novelties of design brought out by the war were developed to a point of actual utilization on railway mounts. A few of these new ideas are briefly described below, however, as they may develop to some importance in relation to railway artillery.

407. Autofrettage is a system of gun-tube construction in which the distribution of initial stresses (which is ordinarily obtained by the shrinkage of concentric rings, one upon the other) is attained in a single homogeneous tube, or better, in one tube and one jacket, through the application of internal hydraulic pressure. This system has not yet been applied to the manufacture of anything larger than field guns. It has been used, however, in the making of the French long-range gun. The 33-meter tube of 21 centimeter bore, used in converting a 34-centimeter, 45-caliber naval gun into a long-range gun, was placed in the gun cold and expanded by hydraulic pressure. The hoop placed over the projecting portion of the tube was likewise put on cold and the tube expanded into it by hydraulic pressure.

408. "Artillery C" is a term used by the French to designate an experimental system of M. Charbonnier, in which copper rotating

bands are replaced by machined rifling on the shell. The rifling in the gun is made to correspond, and the shell is made longer and heavier than normal. Experiments have been made in 75 and 155 millimeter field guns along this line, in which shells up to 9.5 calibers in length and weighing 60 per cent more than the regulation shell, were fired and attained ranges up to 35 per cent in excess of the range for the standard shell.

409. The turbo-cannon of Lieut. Delemerr-Mayo, of the French Army, is a gun without rifling, in which the rotational velocity is given the projectile by the impact of the powder gases on special vanes. Such tests as were made indicated rotation of the projectile, but no further conclusions were possible.

410. Muzzle brakes, or gas deflectors, for reducing recoil have been experimented on by Lieut. Bory and Capt. Galliot, as well as in the American Ordnance Department. The best results so far attained in experiments are a reduction of 40–60 per cent in recoil energy on the 75-millimeter field gun and a reduction of 83 per cent on a 3-inch seacoast gun. Measurements taken of the atmospheric pressures in the case of the seacoast gun indicate that the gun crew is not in any danger from the outwardly deflected gas stream.

411. Recoil Mechanism.—The various recoil systems were discussed very fully in section 1, and the following points were brought out:

(a) Cradle recoil with air recuperator is the highest development of recoil systems.

(b) Top carriage recoil is obsolete, being particularly unsuited to high-angle fire.

(c) Sliding recoil is unsuited to small guns because the time of firing can not be reduced below a minimum which is too great for the efficient service of such guns. Without the use of a cradle, it is unsuited also for the very largest guns, on account of excessive trunnion forces. It is very satisfactory for medium and large calibers.

(d) Rolling recoil is similar to sliding recoil in regard to the points mentioned above. A rolling mount requires less track preparation than any other type. In all known types of rolling mounts cradles have been used, making them more complicated than the sliding mounts.

412. Mounts with rolling or sliding recoil must be pushed back into battery after firing. This is accomplished on the lighter of the sliding type mounts by the use of a hand translating mechanism, consisting of a crank, a train of gears, and some chains leading to one or more of the axles. In the mounts constructed to date one translating mechanism is provided on one or two of each four to six

axles, and the ratio of gearing is from 100 to 132 turns of the handle to one revolution of the wheel. The mount can be moved at the rate of from 3 to 5 feet per minute. With the mounts having rolling recoil, the length of recoil is considerably greater and a gasoline-driven winch, mounted on the front truck or span bolster and taking up a cable fastened to the track ahead, is preferred for returning the mount to its firing position. For this sort of movement, experience has shown that the rolling friction is much greater than is ordinarily assumed for railway work. The tractive effort on a level track with the American 16-inch howitzer ran up to 50 pounds per ton. On the heaviest sliding mounts electrical translating mechanism is provided. This is very convenient, of course, but requires a power plant and complicates the design and accessory equipment. Manpower is always available and is reliable. Electrical equipment has the bad habit of failing when it is needed most.

413. ELEVATING MECHANISM.—Elevating mechanisms are so diverse in type, and the speed of operation of the piece is so largely dependent on them that a somewhat lengthy consideration is felt to be justified. First the requirements of the mechanism will be discussed, and then their practical embodiment will be described.

414. The requirements of an elevating mechanism are that it shall:

(*a*) Afford proper extent of elevation.
(*b*) Give proper ratio of handwheel to gun movement.
(*c*) Be sufficiently strong to withstand shocks of fire.
(*d*) Be efficient enough to allow operation at the required speed with the power available.
(*e*) Be simple in construction and easily maintained.

415. In regard to extent of elevation, (*a*) above, ideas have been modified considerably by the experience of the European War. For howitzers, a maximum elevation of 65 degrees is required to give the desired plunging fire. For guns there may be objectives at long ranges of such size that the high dispersion incident to fire at maximum range is not disadvantageous. Therefore the mount should always allow sufficient elevation for the gun to attain this maximum range. For medium caliber guns at medium velocities, this approximates the theoretical 45 degrees. For large guns and high muzzle velocities, however, the decreased air resistance at high altitudes so far increases the range that the maximum appears to be attained at from 50 to 55 degrees. The long range 210-millimeter German gun which operated at a muzzle velocity of 1,500–1,600 meters per second, was fired at an angle of at least 55 degrees. The French 220-millimeter gun will be mounted with provision for an elevation of 55 degrees.

416. The ratio of handwheel to gun movement, (*b*) above, will be expressed as the gun movement in degrees over the corresponding handwheel movement in turns, 2/1 meaning 2 degrees of gun movement per revolution of handwheel. This ratio should be such that the necessary fine adjustment for laying can be had, on the one hand, and that the gun may be depressed and elevated rapidly for loading. On some of the older mounts, the ideal for both requirements is sought by the use of a slow elevating gear and a quick loading mechanism together, as on the 190, 200, and 240 millimeter French howitzers. Railway artillery, however, is not called upon for extreme speed in firing, and late designs of mounts show that a satisfactory compromise can be found in a single mechanism. As an indication of the requirements for accurate laying, it is found that the adjustment of elevation to a precision corresponding to one quarter of the probable error in range, requires setting to within from 1 to 2.5 minutes, depending upon the accuracy of the particular gun considered. Such a setting could easily be made with a handwheel ratio of 1/1 to 2/1. The smaller handwheels can be spun at from 60 to 90 revolutions per minute, which would give a speed of operation to 45 degrees elevation, of from 15 to 45 seconds. This is amply fast enough for railway artillery. Practice shows a variation of this value per turn of handwheel between about 0.33/1 and 1.80/1. The ratio for the heaviest guns approximate a value of 0.5/1, but as one of them which has an efficient elevating gear, has a value of 1/1, it is thought the lower value is adopted for the sake of mechanical advantage, rather than because it is inherently desirable. The conclusion from the above is that a ratio of 1/1 (1 degree movement of gun per revolution of handwheel) is amply fine enough and that the value may be run up to 2/1 with the less accurate and smaller guns.

417. In reference to strength (*c*) above, the chief forces to be withstood are two. The first is a turning moment due to the powder pressure. In American ordnance design, the center of gravity of the recoiling parts is usually put a short distance below the center line of the gun, so that, as long as the projectile is in the bore, there is a couple due to the powder pressure against the breech, which tends to elevate the gun. The elevating mechanism must be made strong enough to stand this without movement, so that the accuracy of fire will not be reduced. The second force is the moment due to the breech preponderance of the gun when in full recoil. If the elevating mechanism is so constructed that it can not be moved by this couple, then it must be made strong enough to withstand this moment as well, which is usually considerably larger than the one first mentioned. On most heavy mounts (tipping parts weighing over 25,000 kilo-

grams) the elevating mechanism is arranged so that it can slip slightly under the action of this couple, the slip-friction device being inserted ahead of any worm or screw which, of course, are irreversible. The movement takes place only after the projectile has left the bore and does not affect the accuracy of fire. Even in these cases, the gearing seems to be made strong enough to stand this moment, with a safety factor of perhaps two. On the sliding mounts, with fixed trunnions, neither of the above stresses occur, but if the center of gravity of the gun is not exactly coincident with the axis of the trunnions, a turning moment develops as the mount recoils. A turning moment is developed in a similar way with a rolling mount where the trunnions are very likely to be behind the center of gravity, as on the British 14-inch mount.

418. Under the above analysis the turning moment to be resisted is calculated or assumed. With the heavier guns the moment becomes more and more difficult to provide for. Ordinarily, one tooth of a pinion must take it. Next, a second pinion with another rack may be added. After these, plain worms, Hindley worms, and screws, give possibilities of progressively increasing strength within the practicable limits of the mechanism.

419. The efficiency (*d*) above, required of the gear, depends upon the work to be done in elevating the gun and the power available. The work is, in general, that of overcoming the friction of the trunnions in their bearings. With the small guns of light weight and supported by trunnions of small radius this is comparatively insignificant, but with heavy guns and large diameter trunnions, particularly with the sliding mounts, where particularly large trunnions are required, this friction may be considerable. When the work of overcoming this becomes too large, recourse is had to various antifriction devices, which support the gun during elevation but give under the shock of fire and allow the main trunnions to take that shock. These devices operate either by reducing the coefficient of friction, as with the roller bearings, or by reducing the relative movement, i. e., using a very small radius auxiliary trunnion (St. Chamond type). Some devices combine these two ideas, and the arrangement on the 280-millimeter German mount, plate 388, is perhaps the best which has been seen. In practice these devices seem to be adopted almost universally for mounts with tipping weights exceeding 25,000 kilograms. The second factor concerned, as noted above, is the power available. This is preferably hand power and may be approximated as varying from one-tenth horsepower, for a man spinning a handwheel for a short time, to perhaps 1 horsepower for four men working at top speed on long radius cranks. Some French mounts have 7½ horsepower electric motors for elevating and the British 14-

inch has a 20–30 horsepower gasoline engine. For the sake of simplicity of construction, operation, and maintenance, it is highly desirable that hand power be used where possible, and it is believed that, if efficient gear trains and good antifriction devices are employed, this is possible even with the heaviest gun; and even where power elevating is used, the hand mechanism should always be provided as an auxiliary.

420. The required efficiency of the gear train can be approximated from the preceding considerations. Manifestly, it is a function of the number and character of the mechanical elements in the train. These are, usually, spur gears, bevel gears, chains, worms, and screws, with efficiencies falling off in about the order named. Low pitched worms and screws are very inefficient. It is, of course, necessary to make careful calculations on the efficiencies of each individual elevating mechanism but these will always be found to involve two constants which must be assumed, the coefficient of friction in the trunnion bearings and the efficiency of the gear train. The relation of the former divided by the latter is taken as an indication of the efficiency of the mechanism. As an indication of values, data has been taken from proof tests of a number of seacoast carriages, and the efficiency of the mechanisms has been computed. It is found to vary from 0.372 to 2.67 with an average of about 1.14. The gear trains of all these mounts included a worm or a screw and from one to four pairs of bevel or spur gears. Assuming 0.15 for the coefficient of friction, this would indicate a gear train efficiency of from 40 down to about 6 per cent. By contrast, the American 16-inch howitzer with a train of three pairs of spur gears, gives a value of approximately 0.15; that is, a gear train efficiency of about 60 per cent, with a coefficient of friction of about 0.10. This indicates clearly the superiority of spur gears from the standpoint of efficiency. Since the gun of this mount, the tipping parts of which are at least half as heavy as those of the largest gun to be considered, can be elevated in 25 seconds by one man with one hand, it is felt that spur gears give a sufficiently efficient train so that even the largest gun could be operated through them by hand power. The best example of this construction is the St. Chamond 340-millimeter gun mount, plate 427, with a gear ratio of approximately 1/1 and on which the elevating gear is apparently entirely satisfactory.

421. In the matter of simplicity, (*e*) above, manufacture is probably simplest on chains and spur gears, and becomes progressively more difficult on bevels, screws, worms, and Hindley worms. As to maintenance, the difficulties involved are confined largely to the necessity for close adjustment. Within limits, practically all that is required of the chain drive is that the two sprockets be in approximately the

PLATE 427

340-MM. FRENCH GUN ON RAILWAY MOUNT.

same plane. With spur gears, the distance between shaft centers must also be fairly closely maintained. With bevel gears the shaft center lines and planes of the gears must both be exactly maintained. With worms, the shaft distances and the plane of the worm shaft must similarly be kept just right, and with Hindley worms, the position of the worm along its shaft must be exact as well. With the screw, screw and nut must be coaxial, but if they mesh at all, this condition is assured. This indicates that screws, chains, and spur gears are the easiest mechanisms to keep in adjustment, and that bevels, worms, and Hindley worms are more difficult in the order named.

422. The way in which these five requirements are realized may be understood by a study of the various mounts described in section 3, Volumes I and II. The following summary, extracted from section 3, is given, covering some of the points discussed in the preceding paragraphs:

Use of slip-friction device: Almost invariable with mounts whose tipping parts weigh over 25,000 kilograms. Exceptions have screw elevating gear.

Use of antifriction device: Almost invariable with mounts whose tipping parts weigh more than 25,000 kilograms. The single exception has a power drive for the elevating gear.

Mechanism at the gun: Forty-one examples classify as follows:

Curved rack and pinion	29
Straight rack and pinion	1
Worm and wheel	3
Screw and nut	8
	41

Gear train, exclusive of above:

Spur gears only	5
Bevel gears only	6
Spurs and bevels	2
Worm and bevel	17
Chains employed	4

General type of entire mechanism:

Rack and spur gears	5
Rack, worm, and bevels, etc	19

The only types of mechanism which occur with almost or identically the same arrangement of components, on a number of mounts, are the rack with spur-gear train, which is found only in American and French designs, and the rack, pinion, worm, wormwheel, and bevel combination, which is very popular and occurs in American, French, British, and German designs. The chief objection to this latter type of gear is low efficiency, which has necessitated a low ratio of gun to handwheel movement—from 0.33/1 to 0.67/1.

423. The conclusions with regard to elevating mechanism are:

(a) Extent of elevation: To 45–55 degrees for guns; 65 degrees for howitzers.

(b) Ratio of handwheel to gun movement: One to 2 degrees of gun movement per turn of handwheel.

(c) Strength: Usually safeguarded by a slip-friction device. In exceptional cases great strength may be obtained by the use of a screw.

(d) Efficiency: Spur gears most efficient. Screws and worms may reduce efficiency to very low values.

(e) Simplicity: Spur gears, chains, and screws are simplest mechanisms. Bevels and worms to be avoided when possible.

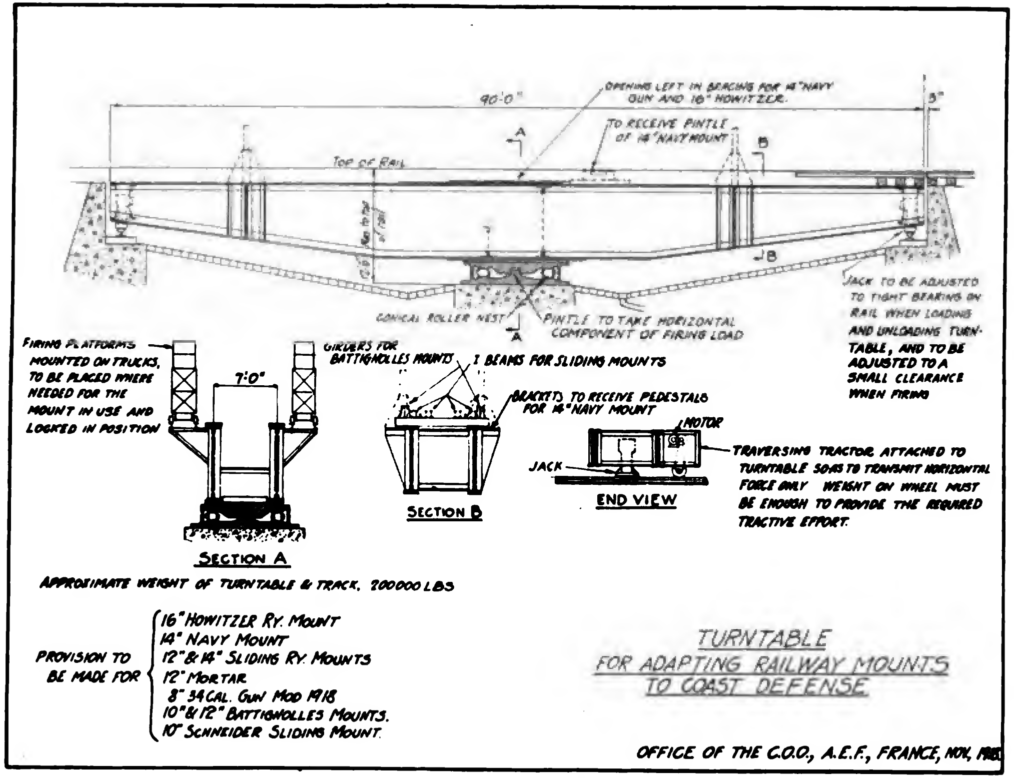
424. Traversing Mechanism.—Traversing mechanisms are discussed in a general way in section 1. A detailed discussion of the mechanical features of the different schemes follows.

425. Nontraversing mounts must be pointed in azimuth by some extraneous means, as a curved epi or a turntable. These mounts are usually of the rolling or sliding recoil type and have some sort of translating device to bring them back again into firing position. See description of recoil mechanisms above. This same mechanism can be used, of course, to move the gun along the epi for training in azimuth. In the case of a turntable a special rotating mechanism, usually motor driven, is, of course, provided in the turntable itself, plate 428.

426. Railway car traverse, as explained in section 1, allows usually only a very limited movement on the trucks, perhaps 4 degrees. Car traverse in connection with an emplacement is best worked out through the use of a center-plate arrangement built into or attached to the car body; it usually includes roller or ball bearings on which a part or all of the weight of the car body is supported. All round fire mounts of the car traversing type, as at present developed (American 14-inch model E, German 380, 280, 240, and 210 millimeter mounts), require elaborate foundations. Car traverse may be superior to top carriage traverse for a wider range of fire than can be obtained from the trucks, with guns which are not so powerful but that a rapidly built emplacement is possible, yet which are so large that top carriage weight is comparable with car body weight. So far as is indicated by present practice, however, this type of traverse is best applicable to high-powered guns requiring only limited traverse in the mount and firing usually from an epi.

427. Top carriage traverse, as noted before, is suited to a maximum traverse of from 10 to 360 degrees. The top carriage consists usually of cast-steel side frames carrying the trunnion bearings in which the

PLATE 428


90'-0"
3"
OPENING LEFT IN BRACING FOR 14" NAVY GUN AND 16" HOWITZER.
TO RECEIVE PINTLE OF 14" NAVY MOUNT
TOP OF RAIL
A
B
CONICAL ROLLER NEST
PINTLE TO TAKE HORIZONTAL COMPONENT OF FIRING LOAD
JACK TO BE ADJUSTED TO TIGHT BEARING ON RAIL WHEN LOADING AND UNLOADING TURNTABLE, AND TO BE ADJUSTED TO A SMALL CLEARANCE WHEN FIRING
FIRING PLATFORMS MOUNTED ON TRUCKS, TO BE PLACED WHERE NEEDED FOR THE MOUNT IN USE AND LOCKED IN POSITION
7'0"
SECTION A
GIRDERS FOR BATTIGNOLLES MOUNTS
I BEAMS FOR SLIDING MOUNTS
BRACKETS TO RECEIVE PEDESTALS FOR 14" NAVY MOUNT
SECTION B
MOTOR
JACK
END VIEW
TRAVERSING TRACTOR ATTACHED TO TURNTABLE SO AS TO TRANSMIT HORIZONTAL FORCE ONLY. WEIGHT ON WHEEL MUST BE ENOUGH TO PROVIDE THE REQUIRED TRACTIVE EFFORT.
APPROXIMATE WEIGHT OF TURNTABLE & TRACK, 200000 LBS
PROVISION TO BE MADE FOR
16" HOWITZER RY. MOUNT
14" NAVY MOUNT
12" & 14" SLIDING RY. MOUNTS
12" MORTAR
8" 34 CAL. GUN MOD 1918
10" & 12" BATTIGNOLLES MOUNTS.
10" SCHNEIDER SLIDING MOUNT.
TURNTABLE
FOR ADAPTING RAILWAY MOUNTS
TO COAST DEFENSE
OFFICE OF THE C.O.O., A.E.F., FRANCE, NOV, 1918

gun cradle swings, and transoms connecting the side frames. It will be more fully discussed later. The components of the traversing gear should be strong enough to resist the forces tending to rotate the carriage when the piece is fired at high elevations. The ratio of the gearing should be such as to allow of fine adjustment—that is, to one mil. Efficiency is not of as much importance here as in the elevating gear, except, perhaps, for coast defense work. As previously pointed out, this type of traverse finds its best application in mounting the less powerful pieces for all round fire, where carriage weight is small in proportion to car body weight.

428. A discussion of the relative advantages of these systems of traverse is narrowed down by the following considerations:

(*a*) Top carriage traverse is so simple for howitzers and the smaller guns (8 inches or less) that the other types do not merit consideration.

(*b*) Nontraversing carriages have so little advantage in simplicity over the car traversing type that they need not be considered.

429. The question becomes, therefore, one as to the type of traverse to be adopted for heavy guns—specifically between epi curve-car traverse combination and an emplacement top carriage traverse combination. The chief objection to the former is the ease with which the battery may be located by aerial photography; in other words, the difficulty of effective camouflage. The answer to this objection lies chiefly in two considerations; first, that the type of target fired on from an epi is usually such that the gun is placed, delivers the required number of shots, and is then returned from the epi to the base, so that, even though the enemy may know where all the epis are, he is by no means sure just where the gun is, and it may quite easily deliver its fire and retreat before he can be sure of its location and start counter-battery fire. The second consideration is that camouflage has proved ineffective against the various means of detection which have been developed—aerial photography, sound ranging, flash ranging, earth vibration ranging, etc. The Allies found, after the conclusion of the war, that the vast majority of the German batteries had been exactly at the points where these various agents had indicated them to be. In the special cases known where careful and effective camouflaging was worth while, for instance for fire of destruction against the bridges east of Metz, the mounts were in position for a long period, but, on the other hand, they were firing at practically a single target, and needed no epi curve, car traverse being ample for the service. With top carriage traverse, on the other hand, ordinarily either no more traverse is realized than with the other type or a special foundation has to be installed, which, with heavy guns, is a very difficult and time-consuming job.

430. The general conclusions with regard to traversing mechanisms are that two types should be considered for services as follows:

(*A*) For heaviest cannon (14-inch 50-caliber guns and 16-inch 25-caliber howitzers): Top carriage or car traverse as wide as stability will allow, using outriggers to take most of the horizontal component of the force of recoil. These same mounts should be so designed as to be capable of operation as rolling mounts if desired and be equipped with traversing rollers and a base ring of the 14-inch model E type for service in coast defense.

(*B*) For medium-powered cannon (10-inch 50-caliber and 12-inch 25-caliber howitzers): Car traverse with wide angle of fire, plates 59 and 60.

431. Gun Carriage.—Most of the components of the gun carriage have already been discussed, but there remain to be mentioned some facts regarding the types and construction of the main frame and the types and construction of pintle and traversing rollers.

432. The main frame of the carriage consists normally of two side members which support the trunnion bearings; and connecting transoms and perhaps a racer. In American and early French practice these parts are uniformly steel castings. Later French and English practice, however, is to build these parts up out of structural shapes and plates.

433. Such practice appears entirely satisfactory, providing provision is made (by additional clearances, etc.) so that the greater flexibility of the structural, as compared with the cast frames, can not cause trouble.

434. Pintle and roller arrangements are of two types. The first, or front pintle type, has a large vertical pin under the front of the carriage, around which the carriage swings. Rollers, usually spring supported, are provided under the rear end of the carriage, and these travel on a special track on the base, or railway car. This type is exemplified, for instance, in the Batignolles mounts and the American 16-inch howitzer. The advantages of such a top carriage are comparatively small forces on the traversing rollers, due to the relatively long lever arm at which they act and great simplicity of construction, facilitating both original manufacture and field maintenance. The disadvantage is that the work involved in traversing is large in proportion to the distance between the pintle and rollers, and because of the large radius of the roller path the type can be used on railway mounts for limited traverse only. The second, or center pintle type, is provided with cylindrical pintle (either a pin or a large radius surface) and a complete circle of conical traversing rollers or balls, both concentric with the carriage. The rollers circulate between conical paths on the base ring and racer, and constitute a roller bearing; the balls, varying in diameter from 4 to 8 inches, circulate between two

grooved paths of circular cross section on the base ring and racer. Both rollers and balls take the entire shock of fire directly. The radius of the roller or ball path is made as small as possible to reduce the work of traversing. The advantages of this type are that a minimum traversing force is required and that the apparatus is sufficiently compact to allow all-round fire in the limits of railway clearance. The disadvantages are the heavy loads which must be carried by the traversing rollers, or balls, and the comparative complexity and exactness required in fabrication, especially in the case of the rollers.

435. The conclusion from the above is that the center pintle type would be most usually employed on railway mounts for medium howitzers and light guns, and for heavy guns and howitzers in connection with some type of separate base ring. The other type will be employed for heavy howitzers and medium and light guns when a greater carriage traverse (10 degrees) than can be secured in car traverse (4 degrees) is desired.

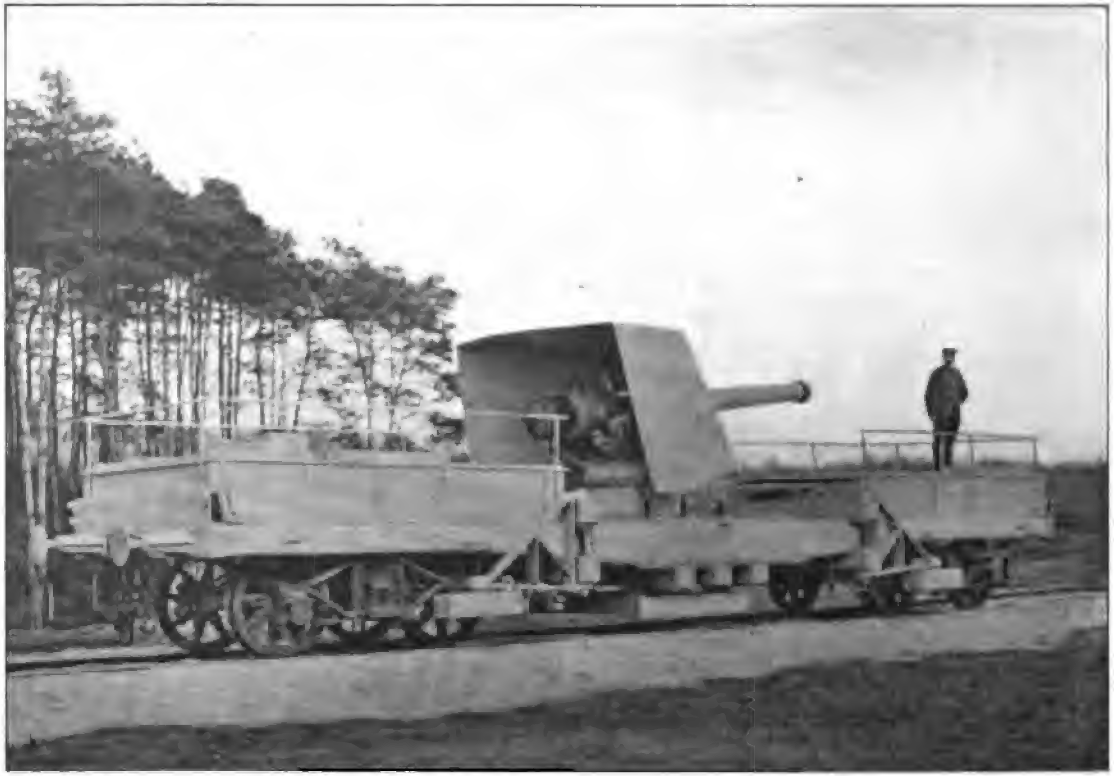
436. Railway Car Body.—Railway car bodies are, with the exception of certain improvised French mounts, always of structural steel and are of two types, flat car and girder.

437. The car bodies of the first type may be merely flat cars of the ordinary freight pattern with the carriage mounted on top of them, as in the case of the 155-millimeter howitzer, plate 429, the 240-millimeter gun, plate 237, or the 194-millimeter gun, plate 431. This type is simple, sturdy, and satisfactory for these mounts.

438. In most cases, however, the height of the gun carriage is such that headroom demands a drop frame type of flat car body. This type is illustrated by the 200-millimeter howitzer, plate 10, the British 12-inch howitzer, plate 432, and the American 8-inch gun, plate 88. Experience has shown two defects with this type of flat car body, one the difficulty of making it stiff enough to prevent undue deflection under the load of the gun, thus perhaps causing deflection of the gun carriage base ring and cramping or jamming of the traversing mechanism; and the other is the same as that experienced with commercial drop frame flat cars, viz, their inability to stand under the severe buffing strains to which they are subjected in coupling, and being hauled over the road, with heavy trains.

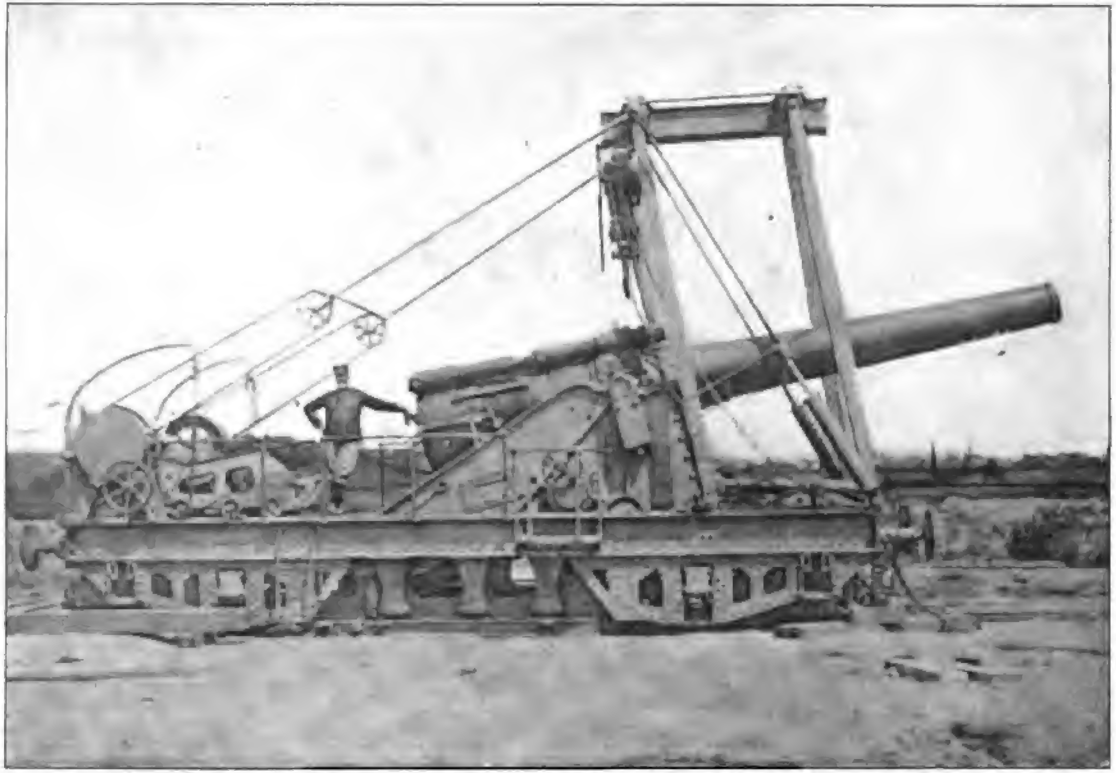
439. The girder type of car body is employed when the weights become too great to be carried on the ordinary flat type. Practically all of the larger caliber mounts furnish examples of this type. This can, of course, be made as strong and as stiff as occasion demands. Only one point needs to be mentioned, and that is the necessity for rigid cross bracing between the two side girders. The lack of such sufficient bracing results in racking or weaving of the side girders relative to each other and the binding of the gun trunnions in their supports breakage of trunnion caps, and the like. There must be actual contact

PLATE 429



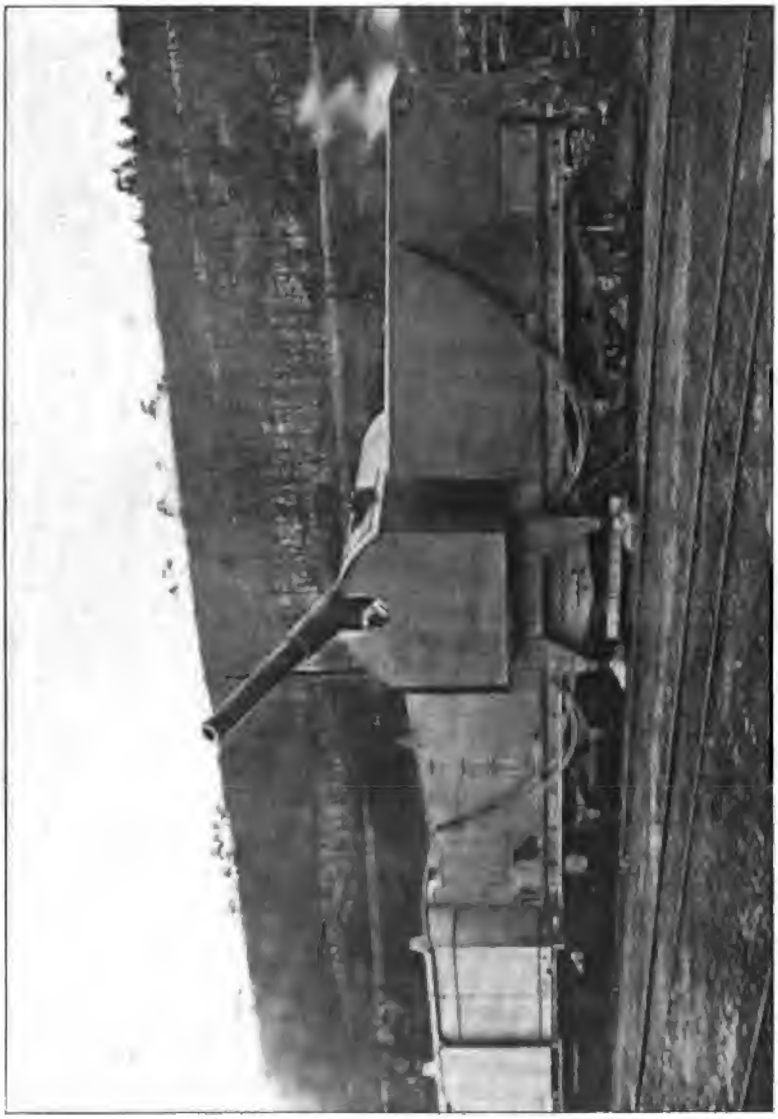
155-MM. HOWITZER (FRENCH) ON RAILWAY MOUNT.

PLATE 430



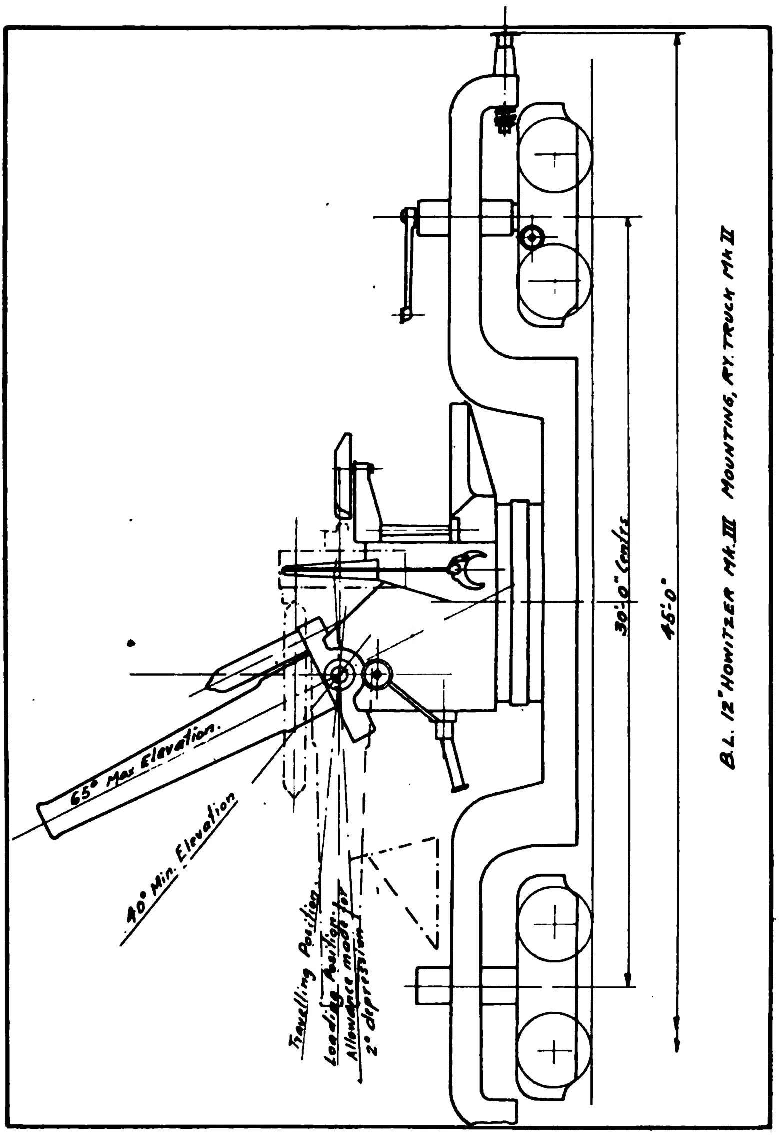
240-MM. FRENCH HOWITZER ON RAILWAY MOUNT.

PLATE 431



194-MM. FRENCH GUN ON RAILWAY MOUNT.

PLATE 432


65° Max Elevation.
40° Min. Elevation
Travelling Position.
Loading Position.
Allowance made for 2° depression
30'-0" Centres
45'-0"
B.L. 12" HOWITZER Mk. III MOUNTING, RY. TRUCK Mk. II

between the webs of the transoms and the webs of the side girders to produce the desired rigidity. The rivets can not be depended upon.

440. An experimental car body of reinforced concrete, plate 433, for a 30-centimeter mortar has been made in France. In spite of the fact that it was successful, this type of construction is not thought to merit consideration where steel is available.

441. Anchorage.—The discussion under section 1 brought out most of the points regarding the existing types of anchorage. They may be summarized as follows:

(a) Mounts requiring no preparation: Must be of the rolling recoil type, can have but very limited traverse, and are in general best suited to the very heavy guns.

(b) Mounts requiring a track platform: Sliding type, suited for heavy guns with limited fire. Strut type, suitable for light and medium guns with 60 to 360 degrees traverse.

(c) Mounts requiring a ground platform: Suited for medium guns with all-round fire, and for heaviest guns with limited fire. (All-round fire for heavy guns in exceptional cases.)

Something remains to be said regarding mechanical details and relative desirability of the different designs under the various types.

442. The first type is, of course, ideal from the standpoint of anchorage. The chief objection, however, is that in all types heretofore constructed it has been necessary to include a recoil system to reduce the maximum pressure on the trucks, and a counterbalancing system to compensate for the extreme muzzle preponderance resulting from mounting the trunnions close to the breech to secure great elevation. Further, the length of recoil along the track (30 to 50 feet) is too great. Improvements now being experimented with on sliding mounts, and detailed in paragraph below, suggest that some means might be adopted to transmit the force directly to the rail instead of through the truck springs. If the car girder were sufficiently strong to distribute the pressure along the track for the length of the mount, pressure on the ties would be nearly as low as on the sleepers of the present sliding mounts, and the pressure on the ground would be halved. If this arrangement did not require too great a weight of girder or too great a complication of jacks it would seem to constitute a most excellent system for guns requiring only very limited traverse.

443. The sliding type of track platform mount requires an epi built with special, long, closely spaced ties, and laid with I-beams in addition to the regular rails. The mount is distinctly at a disadvantage, as compared with the rolling type of mount, in that standard track can ordinarily not be utilized and, indeed, no standard

Plate 433

300-MM. FRENCH MORTAR ON REINFORCED CONCRETE RAILWAY MOUNT.

track materials, except rails, can be used to advantage in the special construction required. A modification of the sliding type mount is now being experimented with, in which the I-beams, or bearing stringers, are fastened to the mount and slide along the top of the ties instead of having them fastened to the top of the ties and allowing the mount to slide over them. This involves the use of dressed ties of extra length in laying the epi, but on the other hand, it avoids the use of a large amount of structural material in making the epi and saves time in its construction. The proving ground tests show that this construction is satisfactory and it offers a distinct improvement over the previous types. It would seem that this scheme might be developed by lengthening the beams carried by the mount, so that enough ties to take the shock would be covered on standard track. With such a modification and the addition, perhaps, of a set of cutters on the mount for surfacing the ties, it would seem that this type might be adapted to operate as satisfactorily on standard track as the former type operates on a spur of special construction. This would have the same advantage as the modified type suggested above, but would, like it, be limited to heavy guns requiring only limited traverse. The sliding type of anchorage, as at present developed, however, still possesses considerable advantages over other types of platform. While it requires the construction of an elaborate epi, this can be built while the mount is still far behind the lines in safety, and when it is finished the mount can be run up, fired, and gotten out again in an absolute minimum of time.

444. The other types of track platform anchorage also employ stringers of beams laid over the ties, to take the vertical component of fire, but they employ guys, rail clamps, struts, spades, and floats to take the horizontal component and prevent overturning. No difficulty is experienced with taking care of the vertical component of fire, but serious limitations have developed with the devices employed to take care of the horizontal component and the overturning tendency. This limitation is of course most marked in an all-round fire carriage operating at right angles to the track, and it will be discussed from that point of view. Rail clamps alone sufficed on the early 155-millimeter howitzer mount, when used on standard gauge track. Horizontal floats, just outside the rails, with jacks attached to the side of the car and screwed down on them, sufficed for the 164.7 and 194 millimeter guns. On the 200 millimeter howitzer it was necessary to place these horizontal floats further out and mount the jacks on the end of swinging arms. This same scheme was tried and found inadequate for the American 6-inch seacoast gun. With the addition of a vertical spade to the float it was tried

on the British 9.2-inch mount and cables attached to deadmen had to be used as a supplement. The next step is the use of struts, with floats arranged at their ends perpendicular to them and bearing against a prepared and properly sloped surface on the ground. This is employed on the American 8-inch gun and 12-inch mortar mounts and the St. Chamond 240-millimeter mount. These seem to mark almost the upper limit of the possibilities of track platform anchorage for all round fire. It is felt that the American 8-inch scheme is a better design than the St. Chamond. It is more effective and can be put in place in one third of the time.

445. Ground platforms, requiring removal of the track and the placing of special work under it, are of two distinct types—the steel or concrete emplacement type and the wooden float and strut type. The former is exemplified in the Batignolles platform, plate 54, for limited traverse carriages, and in the 280-millimeter German platform of steel or concrete, plates 55 and 66, and American 14-inch model E, steel platform, plate 239, for all-round fire. Under this head come also the turntable emplacements used with the German 380-millimeter, plates 417 to 422, and suggested for United States coast defenses, plate 428. The latter type noted above, i. e., wooden float and strut, is merely an extension of the track platform and strut type of mount. It is illustrated by the St. Chamond mounts, plates 51 and 52, and the American Navy 14-inch mount M. I, plate 23. This type allows only of limited traverse. Relative speed and simplicity of installation give a decided advantage to the Batignolles type of ground platform for limited traverse carriages, but the manufacture is, of course, relatively costly and elaborate.

446. A general study of the various types of platforms shows that the permissible load figured on is approximately two tons per square foot, or 20,000 kilograms per square meter. General Peigne's early researches led him to recommend a pressure just half this, i. e., 10,000 kilograms per square meter, and it is undoubtedly true that for horizontal thrusts near the surface of the ground, as in the track platform and strut type of mount, the use of a figure less than 20,000 kilograms is advisable. For vertical stresses or in case of floats deeply buried, the figure is probably perfectly good.

447. Trucks.—The trucks used for railway mounts do not differ from those required for other types of heavy railroad work and no detailed discussion of merit need be entered into. It may be said, in brief, that the outside type of journal should be used if at all possible, for the sake of simplicity, and that both hand and air brakes should be provided. It should also be added that a number of peculiarities which will be noticed on French trucks—such as lack of

equalizers, mounting the centerpin off center of trucks, etc., are improvisations, and are not to be considered desirable for this type of service.

448. Axle loads, during the present war, have been limited by French railways to 17 metric tons. The American Navy 14-inch mount, which exceeded this by about 35 per cent, gave a great deal of trouble, especially from the overheating and scoring of journals and bearing brasses. Mounts with rolling recoil take the firing load directly through the trucks, and this force must be reckoned with in the design. This force is about 35 long tons on English mounts and 27 long tons on the American 16-inch howitzer.

449. Ammunition Supply System.—The ammunition supply system consists of two essential parts, as a rule, a hoisting and translating mechanism for bringing the shell near the gun and a tray or truck for guiding it into the breech. The hoisting and translating mechanism is usually a Triplex block suspended either from a jib crane or an overhead trolley. The jib crane appears to be the favorite for small calibers, and for large calibers where the gun has a fair amount of traverse. The overhead trolley, however, is used in most of the heavy mounts where there is very little traverse, and where the shells can be taken directly out of the ammunition car, or off the transbordeur.

450. The guiding mechanism is a tray onto which the shell is lowered, and which extends into the breech of the gun. On some mounts, as the American 8-inch gun, this is very small and is carried by a second jib crane. Usually, however, a part of it constitutes the top of a stationary shell stand, while another portion can be pushed into the breech when the latter is opened. The shell is then slid along it into the gun, plate 161. Another type consists of a tray provided with wheels, which rolls along a track and part way into the breech of the gun. The tray then brings up against a buffer, while the shell continues to move of its own inertia and comes up to a full or partial seating against the forcing cone. Here the same line of demarkation occurs as in the lifting mechanisms—the plain tray appears to be the favorite for all light shells, and for heavy mounts with considerable traverse. In many cases a negative loading angle is given to assist in moving the shell into the gun. The rolling tray or shot truck is more used with the heavier calibers and mounts having small traverse, plate 162.

451. It is felt that the above indicates the best use of the various arrangements discussed, i. e., the crane and tray arrangement for practically all small guns and the overhead or trolley cranes and shot truck arrangement for heavier caliber guns having very small traverse.

452. Special Arrangements for Coast Defense.—As noted at the end of section 2, the use of railway mounts for coast defense calls

for special characteristics not demanded in land service, viz., provision for operating the sighting, elevating, and traversing mechanisms up to the moment the piece is fired, so that a moving target can be followed and also for operating them simultaneously for the entire battery for volley firing. It is proposed here to discuss the merits of the several possible arrangements for accomplishing this end.

453. The difficulty encountered in the evident solution of leaving men on the mount to carry on these operations is that, in rolling and sliding mounts, and quite probably in all mounts with any but the heaviest anchorage, the shock of fire is so great that this has never been felt to be safe.

454. For the purposes of this discussion, mounts may be divided into three classes:

(*a*) Heavy mounts with top carriage traverse and operating fixed to the anchorage.

(*b*) Light mounts with top carriage traverse and operating fixed to the anchorage.

(*c*) Sliding and rolling mounts traversing by movement along curved epis.

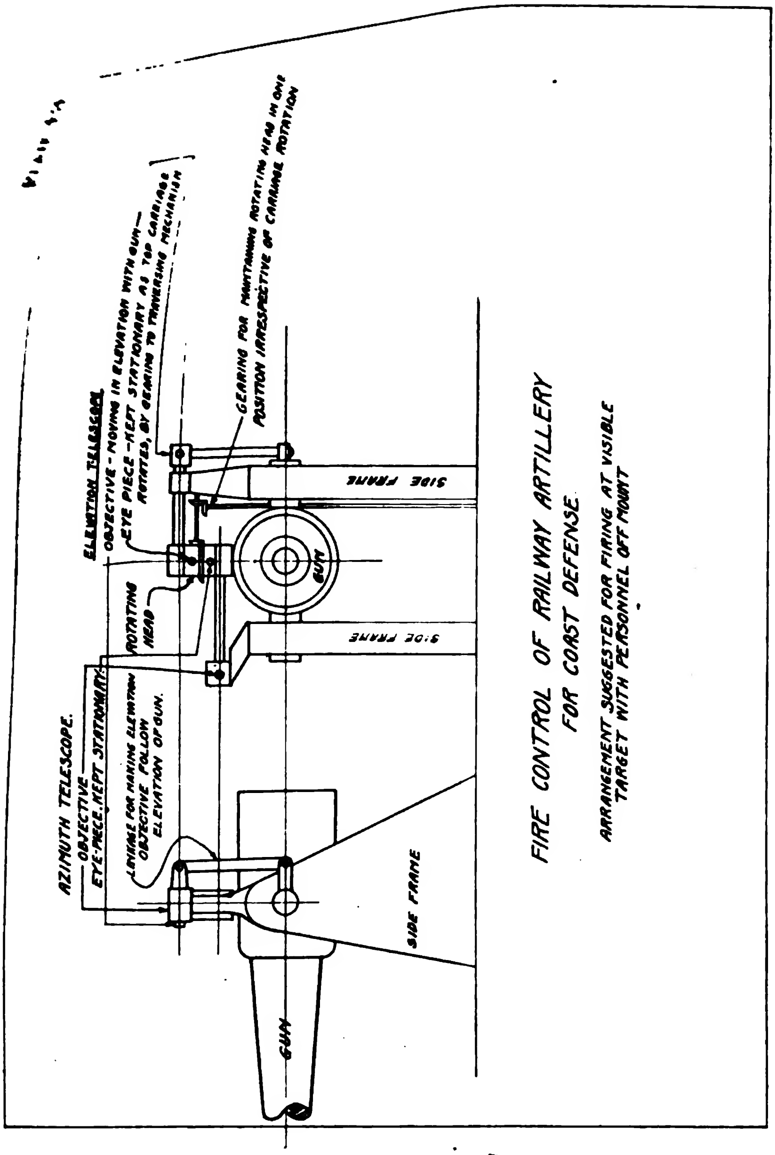
455. With heavy mounts fixed to an anchorage, it is felt that the evident solution mentioned above, of leaving the personnel on the mount, is feasible. This same condition may be realized with heavy guns with small traverse, by mounting them on a turntable, plate 428, which would be electrically operated. The latter arrangement has the disadvantage that turntables must be provided wherever firing is to take place, and the former would seem to be feasible only when an elaborate anchorage is employed. With either of these arrangements, however, the guns can be controlled and fired just as if they were installed in a fort in the ordinary way.

456. With light mounts fixed to an anchorage, the vibration of the structure from the shock of fire would probably be too great to permit the personnel to remain upon it. Three arrangements suggest themselves as possible solutions for this case.

(*a*) Remote control of elevating and traversing mechanism either mechanical or electrical, and observation of azimuth circle and elevation indicator through telescopes. In this case the azimuth circle should be rotatable, so that correction of zero could be made after each shot. For the case where the target is observed directly prism telescopes would have to be employed and arranged as shown in the sketch, plate 434, so that their eyepieces, rotatable around the center of carriage rotation, would be so connected with the traversing mechanism as always to point in the same direction.

equaliz...
imp
typ

F



(*b*) Provision of a simple recoil mechanism on all seats occupied by personnel during firing. The shock and vibration in these mounts is very sudden but not of great amplitude, so that this cushioning mechanism would be very simple. It would, of course, be essential that all optical instruments be arranged so that the eyepiece recoiled away from the observer.

(*c*) Provision of concrete foundations to which the car can be firmly fixed. This is the Luellen idea and would, of course, be equivalent to a gun mounted on a permanent emplacement.

457. The first scheme (*a*) above is quite feasible but somewhat complicated, the third has the disadvantage that fire can only take place at prearranged points, and the second seems best if it can be worked out satisfactorily.

458. With sliding or rolling mounts operating on curved epis, two alternatives are possible:

(*A*) The pointer may be located on the ground, with remote control arrangements for elevation and traverse.

(*B*) The pointer may be located on the mount and his seat provided with a long recoil mechanism, such that the shock of fire will not injure him.

In either case somewhat elaborate apparatus for laying the piece is required. The aiming point may be located at the center of the epi or at some other point. In order to show what may be done, the following four cases will be discussed.

(*a*) Pointer on ground, reference point at center of epi.

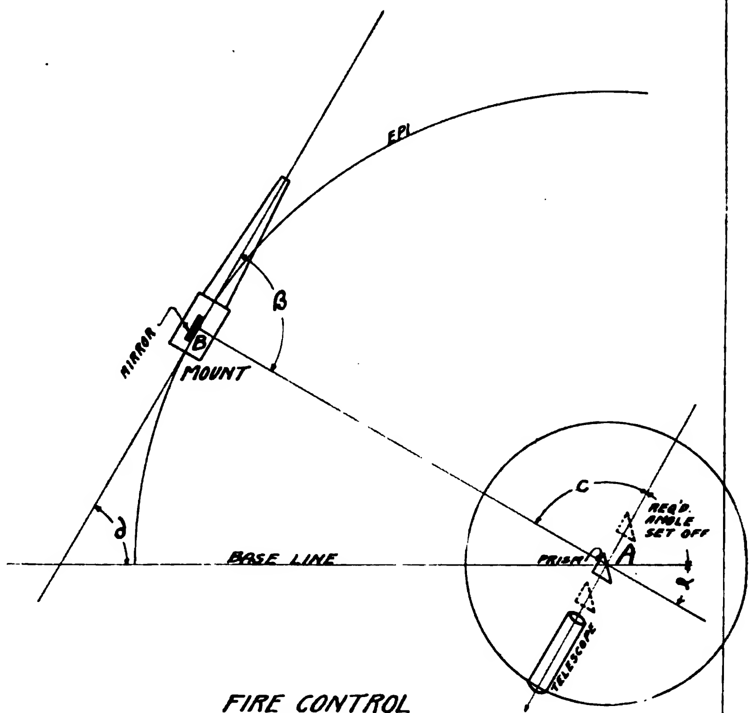
(*b*) Pointer on ground, reference point anywhere.

(*c*) Pointer on mount, reference point at center of epi.

(*d*) Pointer on mount, reference point anywhere.

459. Case (*A*) is illustrated in plate 435A. A mirror is so fixed on the mount that its plane is always parallel to the vertical plane through the center line of the gun. (If the mirror is tilted up to raise the line of sight, so that it moves in a cone instead of a plane, the following reasoning still holds. This may be necessary with a group of mounts controlled from a tower.) At the center of the epi the pointer is located on a platform rotatable about that center. He looks through a telescope *A*, whose angle δ with the baseline can be varied by rotating the platform and can be read on an azimuth circle. His line of sight is turned at right angles by means of the prism *P*, which can be moved back and forth for a distance of perhaps 10 inches each side of the center along the line of sight of the telescope. The operation of training then is as follows: The telescope and rotatable platform are set, either by an assistant from telephone instructions or automatically through mechanical

PLATE 435A



FIRE CONTROL
FOR
SLIDING AND ROLLING RAILWAY MOUNTS
FOR
COAST DEFENSE.

CASE "A."

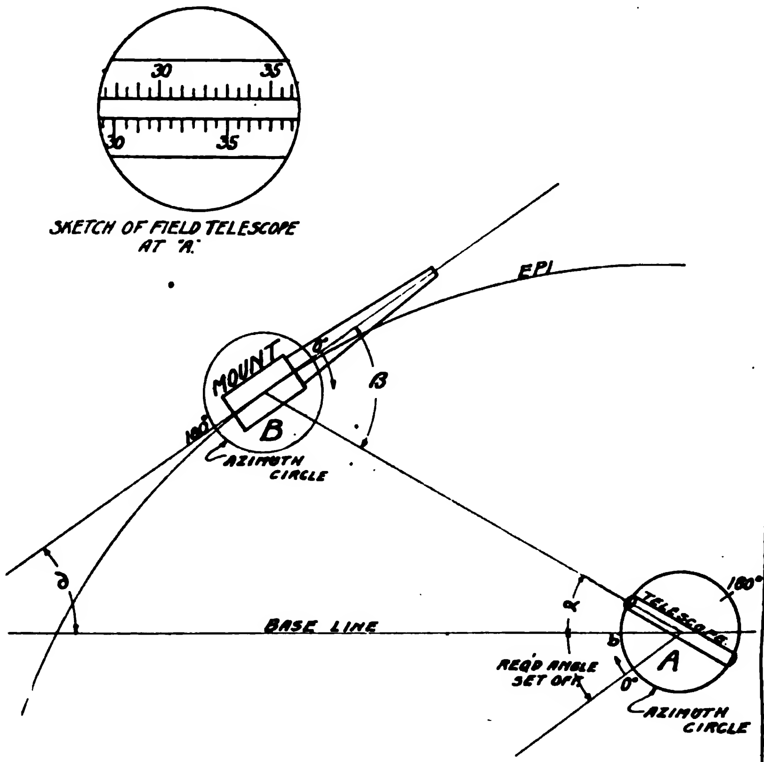
or electrical synchronizing from a central observation point, so that the angle α equals the required deflection of the gun from the base line. The pointer sets his prism directly over the center of the platform (in mid-position), and by operating the controllers of the electric translating motors on the mount he brings it up until he sees the reflection of the prism (or a pointer arranged on it) in the mirror of the mount and registering with the vertical cross hair of his telescope. This would mean that both angles B and C are right angles, and therefore that angle δ equals angle α the required deflection.

460. Due to the irregularities of the track and the following of the mount upon it, the line AB may not always pass exactly through the center point. In such cases the prism may be slid back and forth until this line passes through it.

461. This scheme may be greatly simplified if the observer of the targets is placed in a tower just above A, and arrangements are made so that his telescope and the telescope and platform shown here rotate together. The services of the man setting the azimuth circle at A would then be unnecessary. In actual practice, however, it will likely be found more desirable to place the observer's tower on high ground at some distance from the center of the epi, which will be in low positions not visible from the sea.

462. Case (B) is illustrated on plate 435B. A horizontal azimuth circle and a rod marking its vertical center line are mounted on the gun, so that the rod and the zero of the circle are both in the vertical plane through the axis of the gun. At any point whatever, as A, the pointer is located on a rotable platform with a telescope. Attached to this telescope, and so arranged that it occupies half of the field of view of the latter, is an independently rotable azimuth circle, which can be read against the cross hair through the telescope, and also against the base line at b. The operation of training is then as follows: The circle A is rotated either by an assistant from telephoned instructions, from the observation tower, or automatically through mechanical or electrical sychronizing, from a central observation point. The pointer keeps his telescope trained on the central rod of the azimuth circle on the mount. He then traverses the mount, through remote electrical control, until the reading of the azimuth circle on the mount against the telescope cross hair is the same as the reading of the azimuth circle at A against the same cross hair. Each of these circles occupies half of the field of the telescope, so that his task is simple to bring like graduations opposite. Now, if the circle at A is always kept with the required angle reading at b, then the reading on the circle by the telescope will be required angle + α. If B is made equal to this, then by constructing δ will equal the required angle.

PLATE 435B



FIRE CONTROL
FOR
SLIDING AND ROLLING RAILWAY MOUNTS
FOR
COAST DEFENSE.

CASE "B."

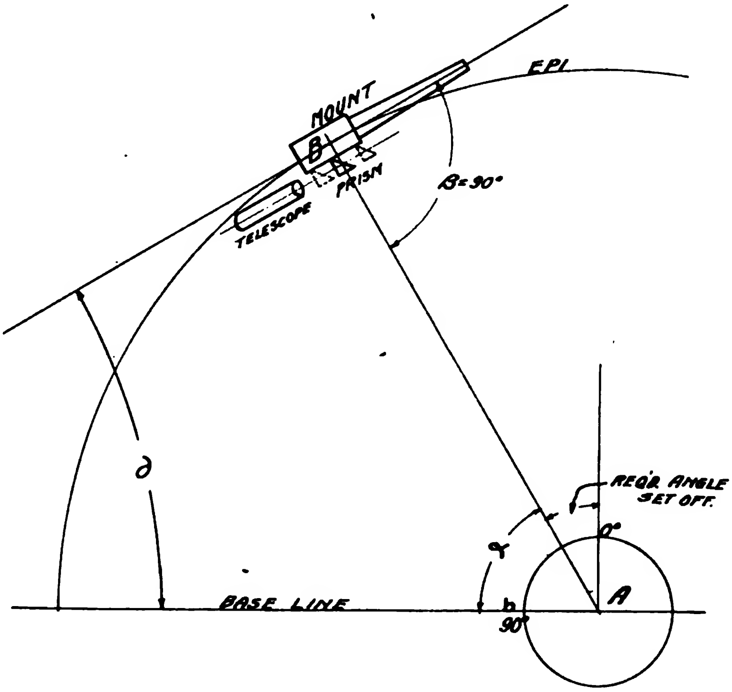
463. Case (*C*) is illustrated on plate 435C. A telescope with a movable prism, similar to that described under case (*A*), is mounted on the mount so that it is always parallel to the vertical plane through the gun center line. At *A*, the center of the epi, a rod and azimuth circle are mounted. The 90-degree graduation of the azimuth circle is placed at *b* on the base line with the graduations decreasing in a clockwise direction. The operation of training is then as follows: The pointer is given the required angle by telephone, or an index on the azimuth circle is moved to it, by an assistant or by automatic mechanical or electrical synchronizing arrangements from a central observation point. The pointer, looking through his telescope, moves his prism to bring the central rod of the azimuth circle on the vertical cross hair. He then traverses the mount until his cross hair intersects the desired graduation or the index on the azimuth circle. The required angle, as set off, is that between *AC* and *AB*. This is evidently equal to angle δ by geometry.

464. Case (*D*) is illustrated on plate 435D. On the mount are located an azimuth circle and rod, similar to that described for case (*B*), and a telescope, rotable about the vertical axis of this circle. At any point, *A*, there is located another telescope and azimuth circle, similar to that used at *A*, in case (*B*), except that it reads the graduation on its own azimuth circle corresponding to the intersection with base line, as *a b*, rather than that corresponding with intersection with telescope line of sight, as in the previous case. This azimuth circle is rotable independently of the telescope and its graduations rise in a counterclockwise direction. The operation is then as follows: An index is set on the graduation of the azimuth circle *A* at the graduation corresponding to the desired deflection from the base line. This may be done automatically as before, or the deflection may be telephoned to the pointer instead. The assistant at the *A* telescope trains this instrument on the rod on the mount and gets the reading on the azimuth circle *B*. He then turns the azimuth circle *A* until this same reading appears at *a*. The pointer at *B* trains his telescope on the azimuth circle *A* and translates his mount till his cross hair intersects the index or the required angular graduation on azimuth circle *A*. From the geometrical construction it is seen that δ equals $B-\alpha$ or the required angle of deflection.

465. Of these various schemes, it is felt that (*C*) is probably the best and (*D*) the most complicated in operation. (*C*) would allow mounting a battery of guns on concentric epis and training them from a single point, which might be in the base of a high observation tower, and which would lend itself admirably to the arrangement for mechanical synchronizing of indices, as suggested. This would be accomplished by having these indices rotated by the same vertical

181768—21——37

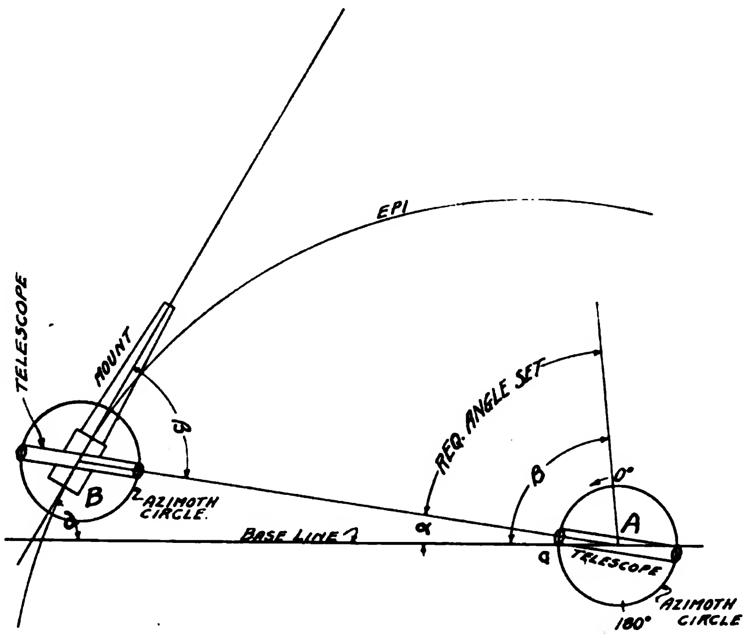
PLATE 435C



FIRE CONTROL
FOR
SLIDING AND ROLLING RY. MOUNTS
FOR
COAST DEFENSE.

CASE "C."

PLATE 435D



FIRE CONTROL
FOR
SLIDING AND ROLLING RAILWAY MOUNTS FOR
COAST DEFENSE.

CASE "D."

shaft which carried the observation telescope through which the target was being followed. Plate 436 gives a rough sketch of such a scheme.

466. Discussion.—The various design details just discussed are so closely interrelated that it is seldom possible to realize an advantage in respect to one of them without a corresponding sacrifice in respect to another. The following tabulation is given of examples drawn from practice to illustrate this interrelation:

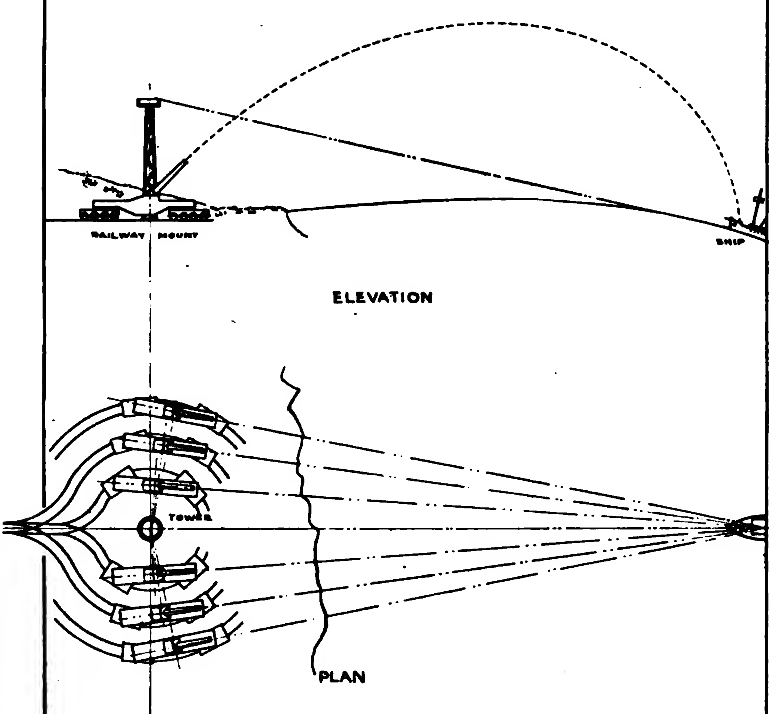
Point gained.	Point sacrificed.	Example.
Cradle recoil (easy anchorage; rapid fire).	Simplicity and rapidity of manufacture; small maintenance.	St. Chamond and Batignolles mounts.
Sliding recoil (simple construction, little maintenance).	Rapid construction of emplacement; rapid fire. (Small guns.)	Schneider mounts.
Rolling recoil (no anchorage)	Same as cradle recoil; rapid fire; minimum number axles.	Armstrong 12 and 14 inch and 14 and 16 inch American mounts.
High elevation (long range)	Balanced gun; gun without counterweight or counterbalance.	Armstrong 14-inch, American 12 and 14 inch.
Rapid elevation (rapid fire)	Simple trunnions; easy operation.	St. Chamond 400-millimeter.
Efficient elevating gear (easy operation).	Compactness of gear; self-locking gear.	St. Chamond 400-millimeter.
Nontraversing (simple construction).	Rapid construction of emplacement; accuracy of laying.	Schneider mounts.
Car traversing (accuracy of laying).	Wide traverse; rapid emplacement.	Armstrong 14-inch; German 280-millimeter.
Top-carriage traverse (accuracy of laying; ability to shift targets).	Simple construction	American 8-inch mount.
No anchorage (rapid emplacement).	Rapid fire; simple construction of mount.	American 16-inch.
Track platform (fairly rapid emplacement; all round fire; rapid fire).	Utmost rapidity of emplacement; simple construction of mount.	American 8-inch.
Ground platform (wide traverse on heavy guns; rapid fire).	Rapidity of emplacement; simple construction of mount.	St. Chamond 400-millimeter.

467. For every class of service, therefore, those characteristics must be chosen which possess the maximum number of points advantageous for the particular service and the minimum number of points which are disadvantageous.

SERVICE REQUIRED OF RAILWAY ARTILLERY.

468. Guns.—In a broad way, the service required of railway artillery may be defined in terms of caliber and range. Referring to plate 58 and the discussion of it at the end of section 2, it appears that the field here discussed lies between calibers of 200 and 500 millimeters and ranges of 10 to 50 kilometers. A single type of gun, of the largest caliber and longest range required would, of course, cover the entire field, but this would manifestly be uneconomical. The subdivisions which should be made in range and in caliber will be considered in the next section.

469. Subdivision by Range.—As noted above, the range to be covered by railway guns extends from 10 to 50 kilometers. The distances at which the guns will be located behind the lines will vary



FIRE CONTROL
FOR
SLIDING AND ROLLING RAILWAY ARTILLERY
FOR COAST DEFENSE

SUGGESTED ARRANGEMENT OF CONCENTRIC EPIS
FOR CONTROL OF ENTIRE BATTERY FROM
CENTRAL OBSERVATION TOWER

PLATE 249

greatly; approximates from practice are given in the table below. The question to be investigated is how many different caliber lengths of guns should be provided for each caliber. The theoretical points covering this will first be brought out and they will then be compared with experience.

470. The ideal aimed at in this subdivision is, of course, to hit each of the individual targets which may be presented at any point in the field above, with a minimum average cost per shot. At a given caliber the cost of charge does not vary greatly with the range. The cost of gun wear varies enormously and it is this factor alone which will be considered.

Characteristics of heavy and railway artillery.

	Type of carriage.	Traverse desired.	Average distance behind front lines.	Maximum range.	Effective range behind enemy lines.	Weight projectile.	Weight explosive charge.	Life of gun, rounds full charge.
HOWITZER.		*Deg.*	*Km.*	*Km.*	*Km.*	*Lbs.*	*Lbs.*	
8-inch British Mk. 6	Caterpillar	360	4	10	6	200	29	6,500
9.2-inch Mk. 2	do	360	4	12	8	290	34	3,700
240-mm	do	360	4	15	11	356	49	2,800
12-inch, 20-cal	R. R.	360	10	20	10	700	109	1,000
16-inch, 18-cal	do	10	10	20	10	1,600	235	550
GUN.								
155 G. P. F	Caterpillar	360	5	17	12	95	22	4,500
194 G. P. F	do	360	5	25	20	176	32	2,900
10-inch, 50-cal	R. R.	60	10	35	25	510	65	620
14-inch, 50-cal	do	5	10	45	35	1,200	181	360

471. Consideration of a large number of actual cases shows that the cost per shot for gun wear varies with the maximum range at which the gun can shoot. These cases as well as theoretical calculations show that the variation in cost per shot is directly as about the cube of the range. On the basis of the above it can be shown that two guns, one having 100 per cent and the other from 70 to 80 per cent of the maximum required range, constitute probably the most advantageous subdivision to cover the above field. A study of the caliber length of the entire existing line of the United States Army cannon indicates a decided grouping around average caliber lengths of 12, 32, and 50. This corresponds approximately to ranges of 100, 75, and 45 per cent. This may be taken as a rough check on the above, because the variation in range covered by these guns is greater than that in question here.

472. Subdivision by Calibers.—As noted before, calibers of pieces are determined by resistance of targets; but there are targets

of two kinds as regards resistance, and these require separate consideration. They are:

(*a*) Targets which require only a certain amount of explosive to destroy them; i. e., which may be demolished by a few large or many small shells.

(*b*) Targets requiring at least a given caliber shell on which a larger caliber represents a waste and a smaller is ineffective.

473. A detailed investigation of the ranges, weights, and rounds life of existing guns indicates that for targets of type (*a*) the cost in gun wear of placing a given weight of projectiles is nearly independent of caliber for ranges above 20 kilometers. (Details of these calculations are given in Appendix II; in such cases hence, subdivision of calibers is of relatively small importance.) For ranges of 20 kilometers or less it becomes progressively more economical to use the smallest possible caliber, sending over the required larger number of shells to accomplish the demolition.

474. For targets of type (*b*) the above investigation indicates that the cost per shot in gun wear varies as about the caliber cubed, and the laws governing the most advantageous subdivision would be similar to those deduced in the case of range.

475. In land warfare it may be said that the targets of type (*a*) occur at ranges (over 20 kilometers total or more than 10 kilometers behind the lines) and under circumstances for which guns are employed (interdiction, long-range destruction of buildings, railroad yards, store yards, etc.); while targets of type (*b*) (fortified works, troop shelters, etc.) are generally fairly close and often demand a plunging fire, thus requiring Howitzers. Hence it may be concluded that:

(*a*) Great subdivision as to calibers is not called for theoretically for guns. Here such subdivision would probably be decided wholly on the basis of other considerations, such as strength of given types of mounts, relative range, etc.

(*b*) Howitzers, however, should be well subdivided, probably with three sizes between the limits given. A subdivision of 400 millimeters or 16 inches, 305 millimeters or 12 inches, 240 millimeters or 9.2 inches, checks well with theoretical requirements. The latter Howitzer will probably be mounted upon a caterpillar and need not be considered here.

476. In coast defense, targets are practically all of class (*b*), paragraph 472. Of necessity, plunging fire will be conducted at shorter

ranges than direct fire; those targets requiring the largest calibers, however, will generally also be at the greatest ranges.

477. Subdivision Based on Requirements of Service.—In the spring of 1918 the allied armies were planning a great offensive for the year following and elaborate consideration was given to heavy artillery requirements. The following condensed tabulation is based on the report of the allied conference on this subject.

FOR DESTRUCTION.

Caliber required.	Range required.	Traverse required.	Time for preparation.
	Km.		—
520 millimeters	18	Limited	Minimum.
400 millimeters		...do	Do.
270 millimeters		...do	Do.
240 millimeters	40	Large	Immaterial.
164 millimeters	22	All round	Not too long.

FOR COUNTERBATTERY WORK.

240 millimeters	22	All round	Minimum.
320 millimeters	22	.....do	Do.

FOR INTERDICTION.

240 millimeters	36	All round	Minimum.
164 millimeters	30	.....do	Do.

The railway guns in other armies also give some information along this line. Some of these are as follows:

Caliber.	Caliber length, maximum.	Range.	Traverse.	Time for preparation.
		Km.	*Deg.*	
232 millimeters	35	16.7	360	Fairly small.
305 millimeters	17.3	13.1	360	Do.
232 millimeters	45	24.7	20	No preparation.
305 millimeters	40	23.1	2	Do.
356 millimeters	45	31.0	4	Do.

The German railway mounts were:

Caliber.	Caliber length, maximum.	Range.	Traverse.	Time for preparation.
		Km.	*Deg.*	
170 millimeters	40	26.0	26	10 minutes.
210 millimeters	45	26.4	95	2-4 days.
240 millimeters	[1] 40	23.1	40	10 minutes.
280 millimeters	40	27.7	40	3-6 days.
380 millimeters	45	26.2 (17°)	Epi.	No preparation.
		55.0 (50°)	360	3 weeks.

[1] A. 30-caliber howitzer is also mounted on this same carriage.

It will be noted that this list includes no mortars or howitzers. The German mortars and howitzers, even up to the largest calibers (420 millimeters), were generally arranged for wheel transportation. The one exception is the 420-millimeter mortar mentioned in the historical introduction. As, however, it has not been possible to obtain really authoritative information on this piece, it is not included above.

478. A further point can be brought out regarding maximum caliber. Only two 520-millimeter howitzers were made, neither of which was ever used on the front. The Germans, it is understood, experimented with a 540-millimeter howitzer, but it was not satisfactory. Both of these facts point to about 400 millimeters or 16 inches as the practical maximum caliber.

479. For coast defense, general conditions will not be outlined, but some idea of the calibers and ranges desired can be gained from the following table showing calibers of mortars, howitzers, and guns now in or contemplated for the coast defenses.

CANNON.

MORTARS.

Caliber	Caliber length, maximum for each caliber.	Muzzle velocity.	Approximate range at maximum elevation allowed by carriage.
			km.
10 inches	10	1,150	9.9
12 inches	10	1,500	14.0

HOWITZERS.

12 inches	20	1,950	20.0
16 inches	18	1,900	20.6

GUNS.

2 24 inches	50	2,400	7.0
3.00 inches	55	2,600	8.0
4.00 inches	40	2,300	8.1
4.72 inches	48.92	2,600	10.3
5.00 inches	50	2,600	9.6
6.00 inches	50	2,600	10.8
7.00 inches	36.6	2,700	15.5
8.00 inches	50	3,350	29.2
10 inches	40	2,250	11.2
12 inches	50	3,200	32.0
14 inches	42.70	2,800	38.0
16 inches	50	2,700	....
18 inches	42.667	2,750	....

Judging from the above, it would seem that almost anything suitable for land warfare would also find a useful place in the coast-defense armament.

480. CONCLUSIONS AS TO GUNS.—The conclusion as to the caliber and length of guns which should be adopted for a railway artillery program should be based upon the foregoing considerations and also upon a comparison with the pieces of heavy mobile artillery which cover the field immediately below.

481. In making this last comparison, account must be taken of the fact that mobile artillery, especially the pieces mounted on caterpillars, can be taken much nearer the front line than railway artillery; to bring this out, a tabulation of characteristics for some heavy wheeled, caterpillar-mounted and railroad guns, is given on page 602. On the basis of this data, another curve similar to plate 58 has been drawn, but this time with abscissæ representing the distance of the target from the front lines. On this, the field covered by each of the guns, also trench artillery and bombing planes, is indicated, plate 437.

482. In view of all of the foregoing, the following is felt to be a logical selection of guns for a railway artillery program:

12-inch 20 to 25 caliber howitzer for destruction and counter-battery work.

16-inch 18 to 25 caliber Howitzer for destruction.

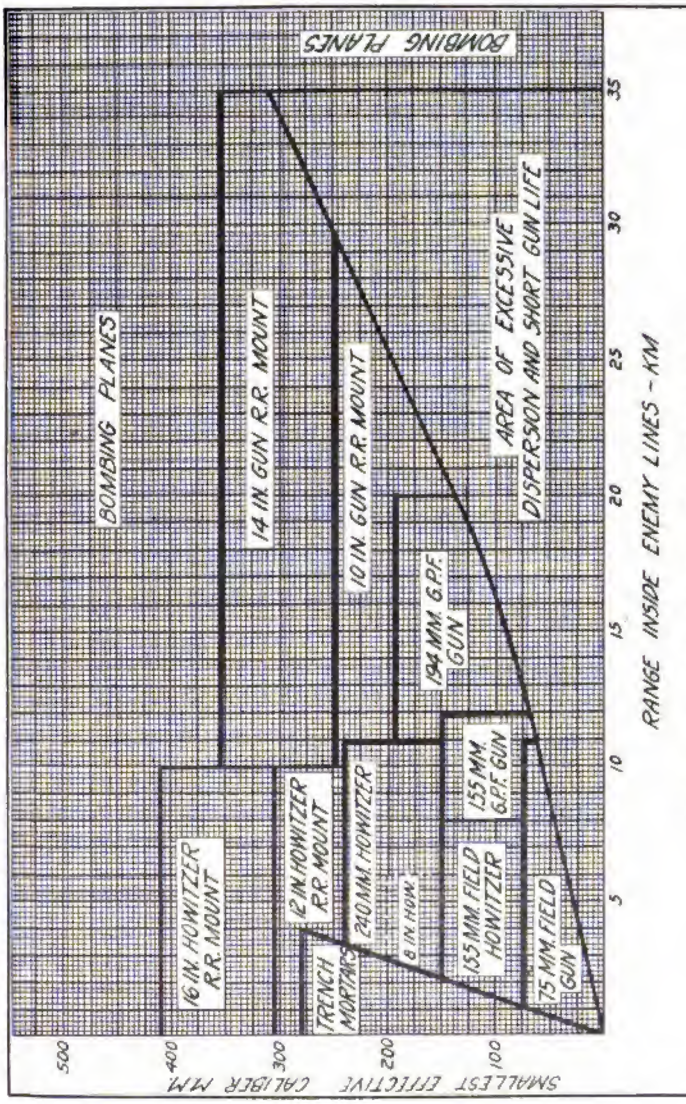
10-inch 50-caliber gun for destruction and interdiction.

14-inch 50-caliber gun for distant destruction.

The fields of these guns have been plotted on the curve, plate 437. It will be noted that the subdivision, in general, follows the requirements of the theory before outlined, except for guns of intermediate range between the 14-inch 50-caliber and the 16-inch howitzer, and the 10-inch 50-caliber gun and the 12-inch howitzer. In these cases, it is felt that most targets, existing at ranges of more than 10 kilometers from the lines, will be of the type which can perfectly well be handled by a sufficient number of smaller shells (10-inch instead of 14-inch and 194-millimeter instead of 10-inch), so that occasions for using the 10-inch and 14-inch guns at short ranges ought to be rare. It is felt that these guns are also well suited to coast defense.

483. MOUNTS.—In section 2 it was brought out that types of mounts (considered on the basis of traverse and anchorage) were assigned according to the number of different targets to be fired upon (amount of traverse required) and the time available for the preparation of emplacement. Other characteristics, as extent of elevation, are determined by the type and size of gun to be mounted. A consideration of the report of the allied conference and of general

Plate 437



ECONOMIC . FIELD OF HEAVY ARTILLERY AND SUGGESTED SUBDIVISION OF MATERIAL TO COVER IT.

practice in the French and British armies shows these requirements to be as follows (these points have already been partially brought out in section 2):

(*a*) For heavy destruction at short range:

Traverse: It is seldom that more than one target need be covered at a time and limited traverse, 10–12 degrees, appears to be satisfactory.

Time for emplacements: These guns often must work close to the front line. It is highly important that they advance, deliver their fire, and retire as quickly as possible. Time for emplacement should therefore be as small as is practicable.

(*b*) For destruction at long range:

Traverse: As above, but 2 degrees is sufficient.

Time for emplacement: Abundant leisure is usually available for construction of emplacement of this class.

(*c*) For counter-battery work:

Traverse: 360 degrees if possible; 60 degrees as a minimum.

Time for emplacement: These pieces must be even more mobile than those for destruction at short range. Time for emplacement should be the minimum consistent with the above traverse (one or two hours).

(*d*) For interdiction:

Traverse: Practice in the armies indicates that limited fire with a fair amount of traverse (60 degrees) is sufficient for railway mounts. This is further justified by the probability that smaller mobile guns on caterpillar mounts will cover the field for which all round fire railway mounts would be required.

Time for emplacement: This should be the minimum consistent with obtaining the traverse required.

(*e*) For seacoast defense:

Traverse: Field of fire 60-180° perpendicular to track. Must be possible to sight, traverse, and elevate the mount up to the moment of fire. It must be possible to do this for a battery simultaneously. This will probably involve much auxiliary equipment.

Time for emplacement: Should be fairly short.

CONCLUSIONS AS TO MOUNTS.

484. Appropriate mounts for each of the guns decided upon, both for land service and coast defense, will next be considered, and the various characteristics which the services demand of it, will be tabulated.

485. TWELVE-INCH, 25-CALIBER HOWITZER.—A mount of the general design of either (*a*) the 12-inch howitzer mount No. 8, or (*b*) the 10-inch, is recommended. The desirable characteristics for the services of counter-battery work and destruction, which this design should possess, gun mount plates 59, 60, and 438 to 448 are, for each of the design details:

Recoil: Cradle, with pneumatic recuperator.

Spur gearing with anti-friction device on the trunnions.

Elevation:

Ratio about 2 degrees elevation of gun per turn of handwheel.

Elevation to 65 degrees.

Traverse: Top carriage, center pintle type, with all round fire.

Railway car: Drop frame flat car type, but strongly reenforced.

Anchorage: Track platform and struts, like American 8-inch.

Ammunition supply: Crane and tray.

For seacoast defense, recoil mechanism or shock absorbers for seats of personnel should be added.

486. SIXTEEN-INCH, 25-CALIBER HOWITZER.—This mount is for fire of destruction only. It is felt that a combination of the top carriage of the 16-inch howitzer, model 1918, MI, the struts of the 12-inch howitzer, the base ring and steel sliding shoes of the 14-inch model E, and certain rolling recoil features fulfills the requirements in respect to time for emplacement, wide angle of fire, and adaptability for coast defense. The following detailed characteristics should be included:

Recoil: Cradle, with pneumatic recuperator.

Spur gearing with anti-friction device on the trunnions.

Elevation:

Ratio, 1.5 degrees elevation per turn of handwheel.

Elevation to 65 degrees.

Traverse: Top carriage traverse, limited fire, 8 to 10 degrees. (Electrical translating motors for counter-recoil and training on an epi).

Railway car: Girder type.

Anchorage: (*a*) Rolling, (*b*) strut, (*c*) base ring.

Ammunition supply: Crane and shot truck.

Recoil mechanism or shock absorbers for seats of personnel and air brakes set by the recoil might well be added, so that the mount might be used either as an emplacement (base ring) or as a rolling recoil mount for coast defense, if the latter method were found necessary.

487. TEN-INCH, 50-CALIBER GUN.—This mount must supplement the long guns on caterpillars on interdiction and long-range destruction work. It must be capable of quick emplacement, should have a wide field of fire and should be able to deliver a number of shots in a minimum of time. A consideration of these points leads to the following recommendations on desirable characteristics:

Recoil: Cradle, with pneumatic recuperator.

Spur gearing with anti-friction device on the trunnions.

Elevation:

- Ratio, 1 degree elevation per turn of handwheel.
- Elevation to 45 degrees.

Traverse: Car traverse:

- On trucks for limited fire of 11 degrees.
- On center pintle for limited fire of 60 degrees.

Railway car: Girder type.

Anchorage:

- Rolling for 11 degrees fire.
- Track platform and struts for 60 degrees fire.

Ammunition supply: Crane and shot truck.

Plates 59, 60, and 438 to 448 show how this design might be worked up. While details have not been investigated, enough has been done on each important feature to demonstrate that nothing is required of it beyond that required of a similar feature on an existing successful mount. It is believed that this type of mount would be well adapted to emergency coast defense.

488. FOURTEEN-INCH, 50-CALIBER GUN.—This mount will be used for the longest range destruction work. It will, in general, be employed some distance back of the lines, ample time will be available for placing it and its field of fire at any time is apt to be narrow. It is recommended that the carriage suggested for the 16-inch, 25-caliber howitzer be used likewise for this gun. An elevation of at least 50 degrees and an elevating gear ratio of 0.5 degrees per turn of the handwheel is recommended.

PLATE 438

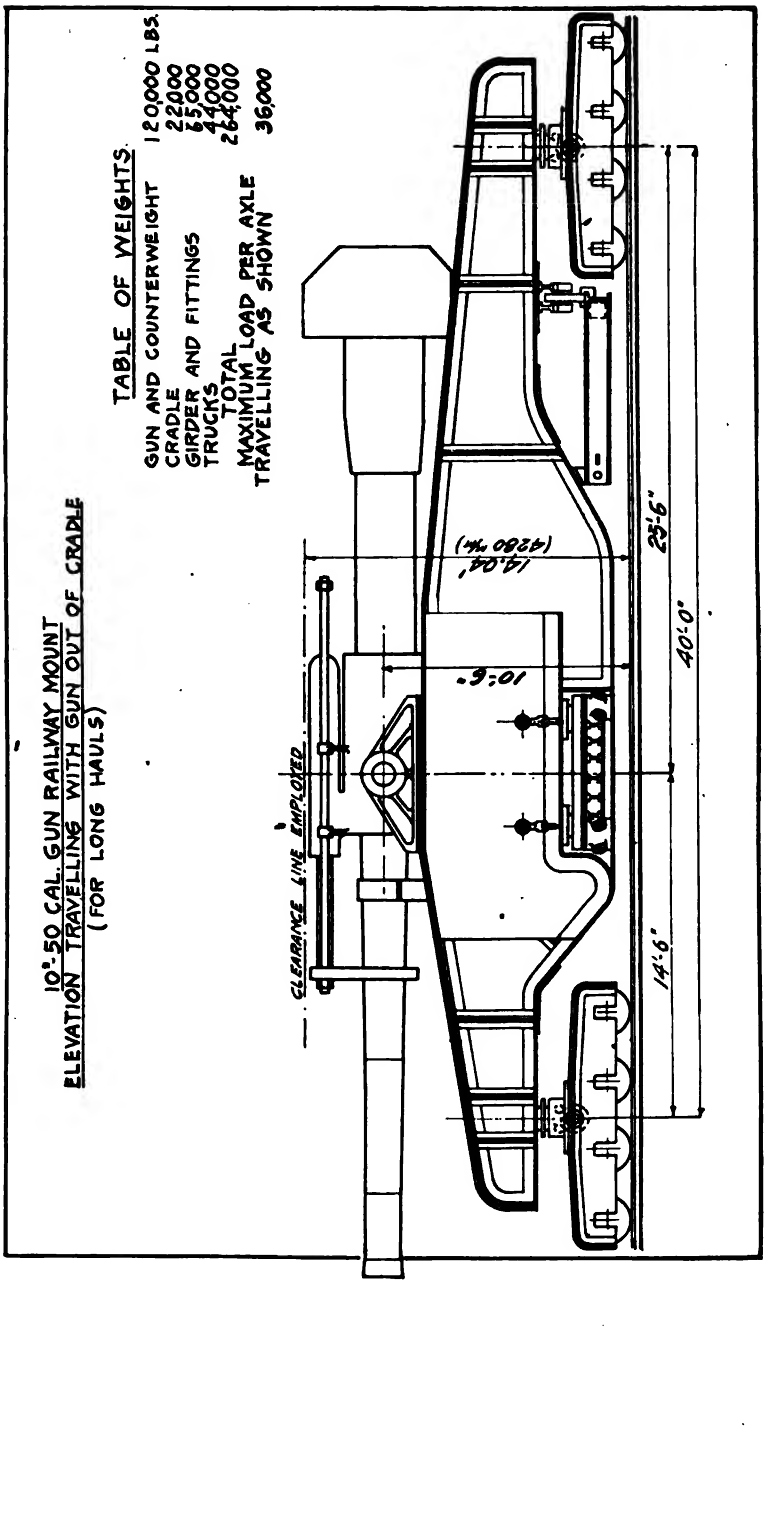
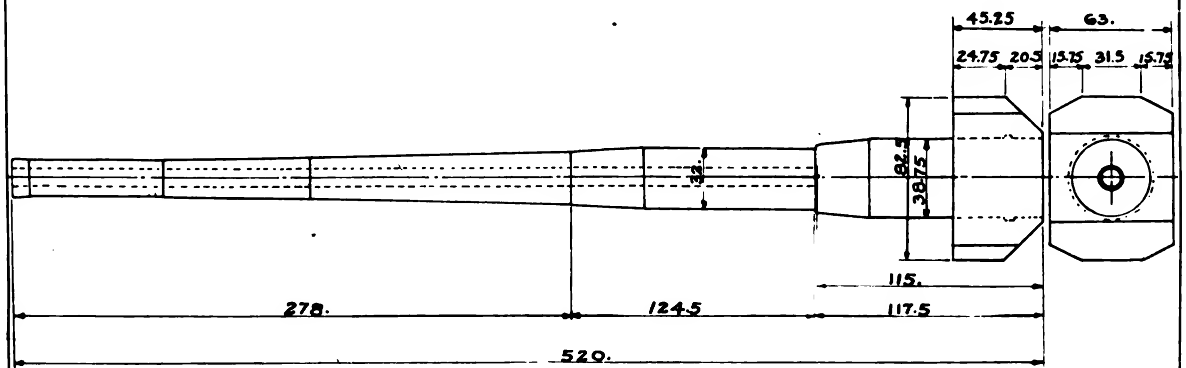

10"-50 CAL. GUN RAILWAY MOUNT
ELEVATION TRAVELLING WITH GUN OUT OF CRADLE
(FOR LONG HAULS)
TABLE OF WEIGHTS
GUN AND COUNTERWEIGHT 120,000 LBS.
CRADLE 22,000
GIRDER AND FITTINGS 65,000
TRUCKS 44,000
TOTAL 264,000
MAXIMUM LOAD PER AXLE TRAVELLING AS SHOWN 36,000
CLEARANCE LINE EMPLOYED
14.04' (4280 %)
10'-6"
23'-6"
40'-0"
14'-6"

PLATE 439



WEIGHTS

GUN AND BREECH	80,000#
COUNTERWEIGHT	40,000#
TOTAL	120,000#

BALLISTIC DATA

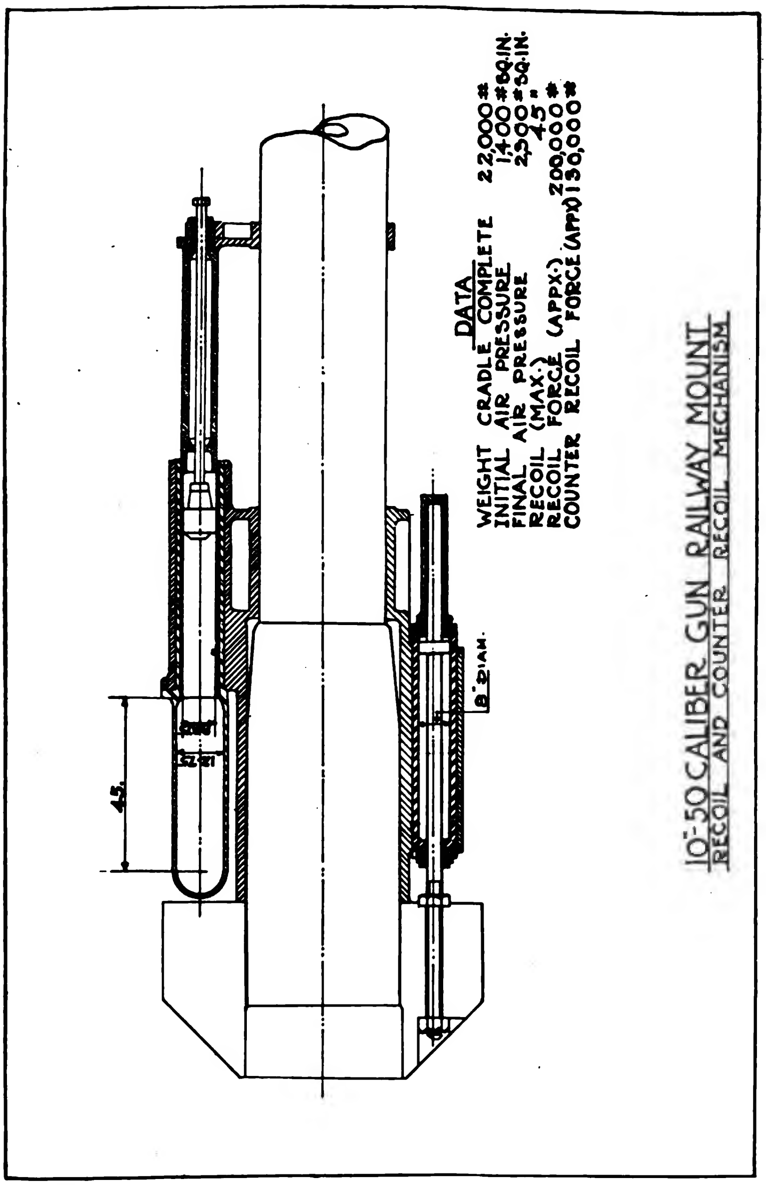
WEIGHT PROJECTILE	510#
WEIGHT POWDER (APPOX.)	170#
MUZZLE VELOCITY	3,000 F.P.S.
RANGE AT 45° ELEV.	35,000 M.

Note: Dimensions and weight of gun obtained by reduction from 16"-50 caliber gun.

10"-50 CALIBER GUN RAILWAY MOUNT

GUN AND COUNTERWEIGHT

PLATE 440



181768—21——38

PLATE 441

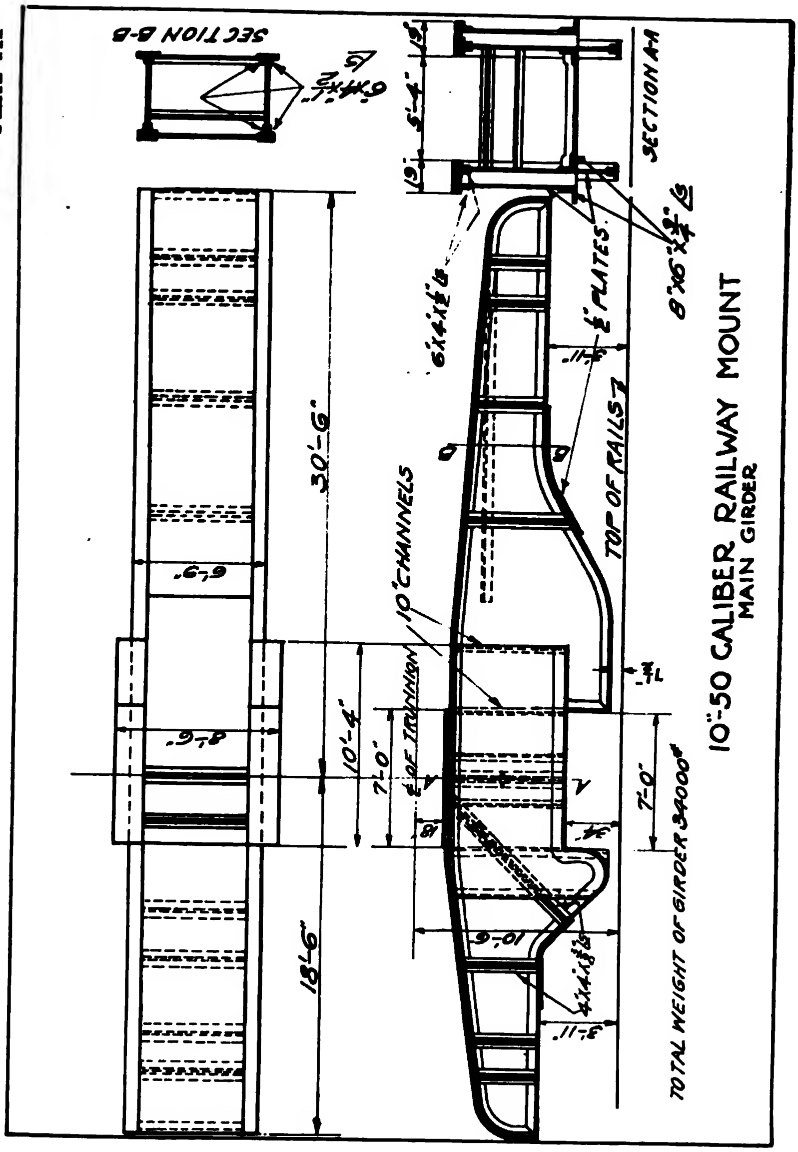

SECTION B-B
6"x4"x½" ∠s
SECTION A-A
19"
5'-4"
19"
8"x6"x⅝" ∠s
¾" PLATES
6"x4"x½" ∠s
11'-8"
TOP OF RAILS
10" CHANNELS
℄ OF TRUNNION
30'-6"
6'-9"
8'-6"
10'-4"
7'-0"
7'-0"
10'-6"
18'-6"
8'-11"
TOTAL WEIGHT OF GIRDER 34000#
10"-50 CALIBER RAILWAY MOUNT
MAIN GIRDER

Plate 442

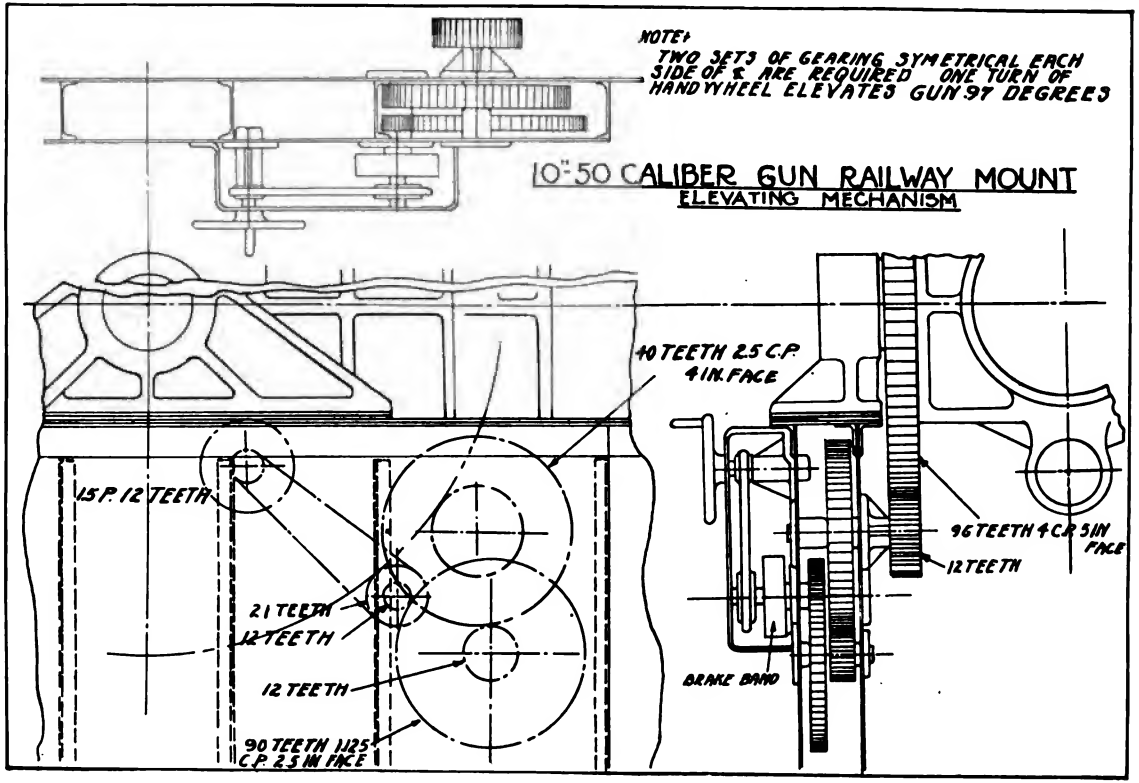
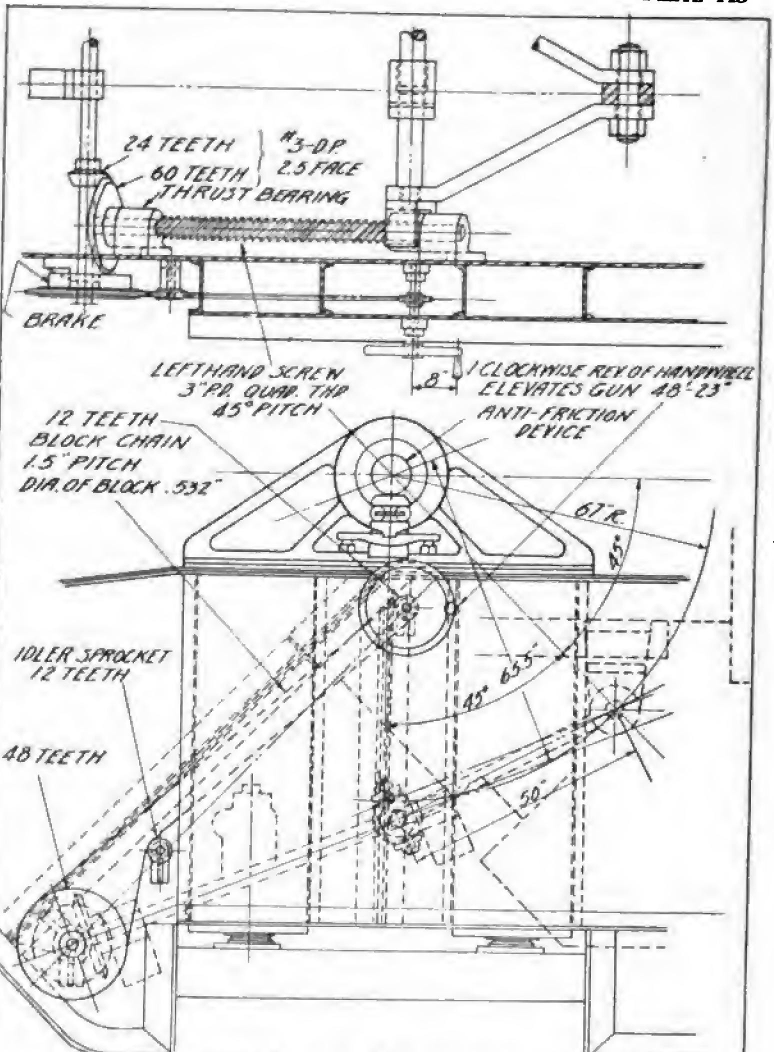
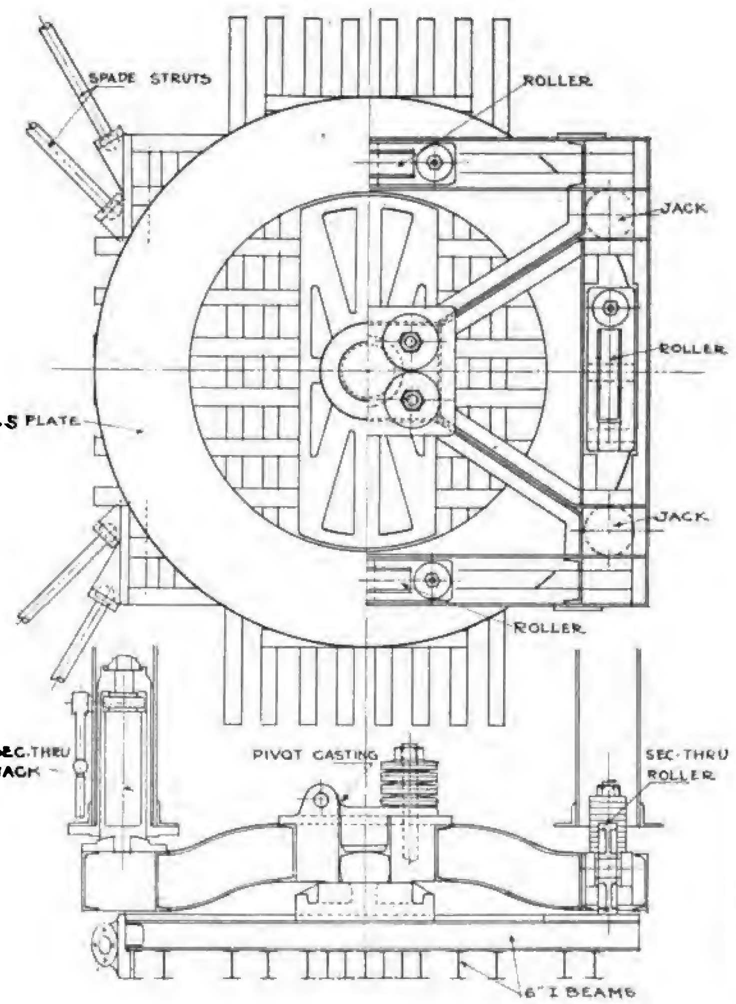

NOTE:
TWO SETS OF GEARING SYMETRICAL EACH SIDE OF ℄ ARE REQUIRED ONE TURN OF HANDWHEEL ELEVATES GUN .97 DEGREES
10" 50 CALIBER GUN RAILWAY MOUNT
ELEVATING MECHANISM
40 TEETH 2.5 C.P. 4 IN. FACE
96 TEETH 4 C.P. 5 IN FACE
12 TEETH
BRAKE BAND
15 P. 12 TEETH
21 TEETH
12 TEETH
12 TEETH
90 TEETH 1.125 C.P. 2.5 IN FACE

PLATE 443



10"-50 CALIBER GUN RAILWAY MOUNT
ELEVATING GEAR

PLATE 444



10"-50 CALIBER GUN RAILWAY MOUNT
FOUNDATION PLATFORM AND RACER.

PLATE 445

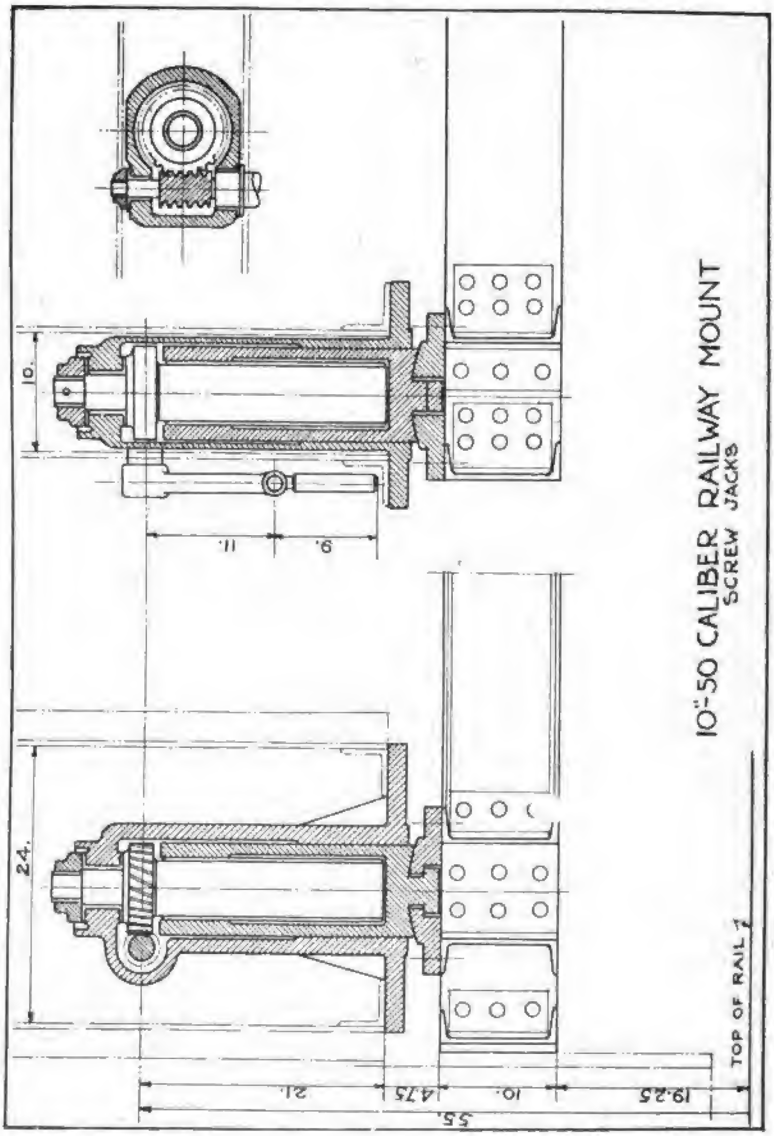

10"-50 CALIBER RAILWAY MOUNT
SCREW JACKS
TOP OF RAIL
24.
10.
11.
9.
21.
4.75
10.
19.25
55.

PLATE 446

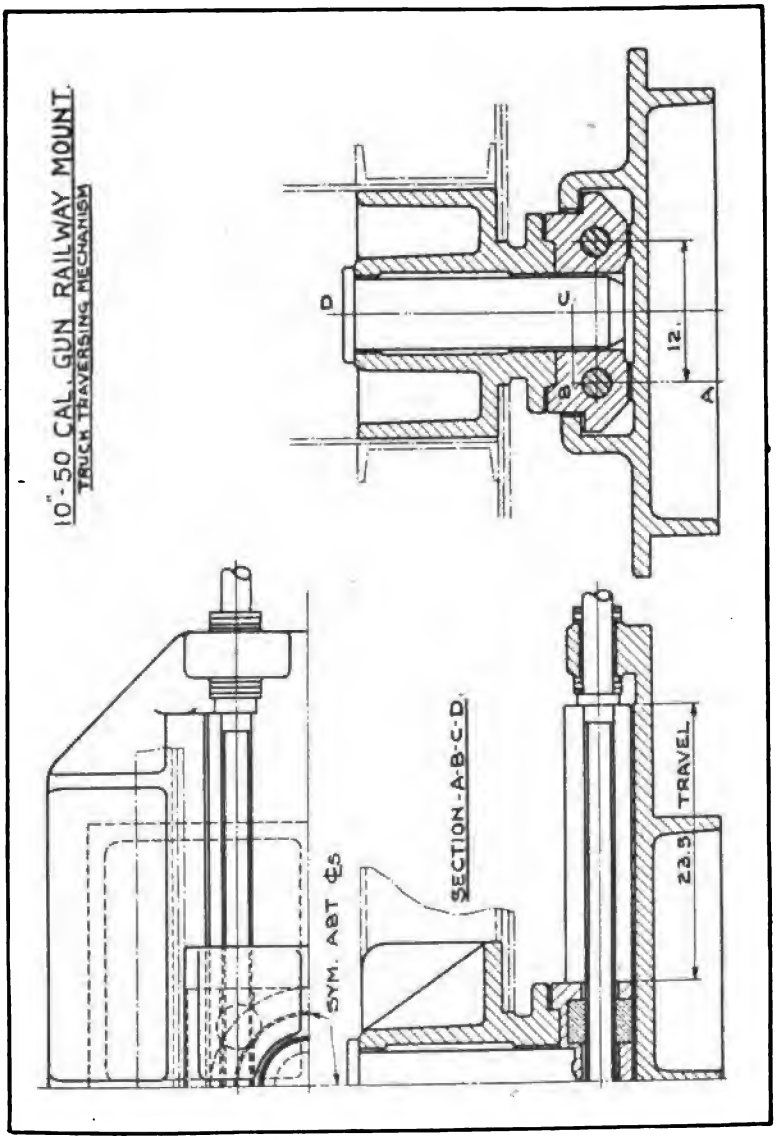
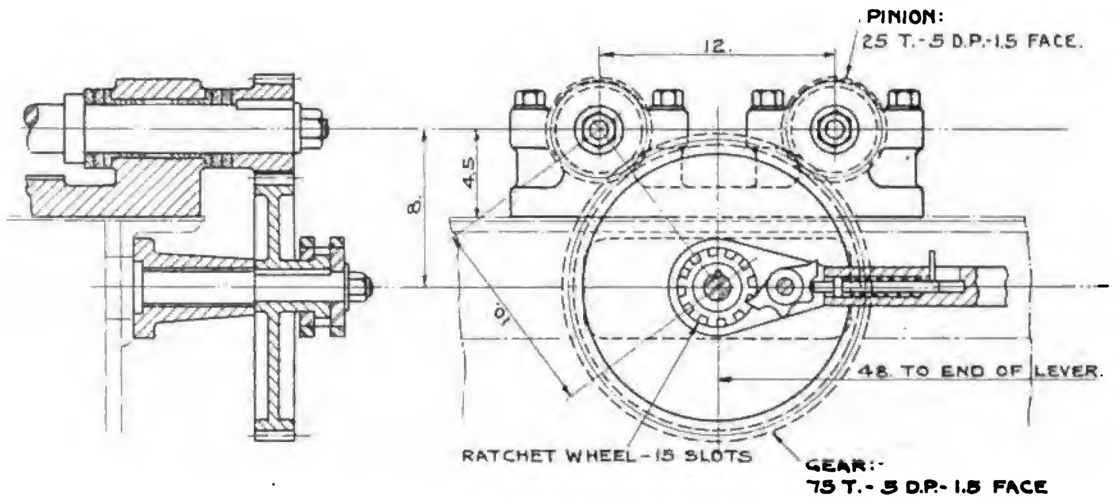
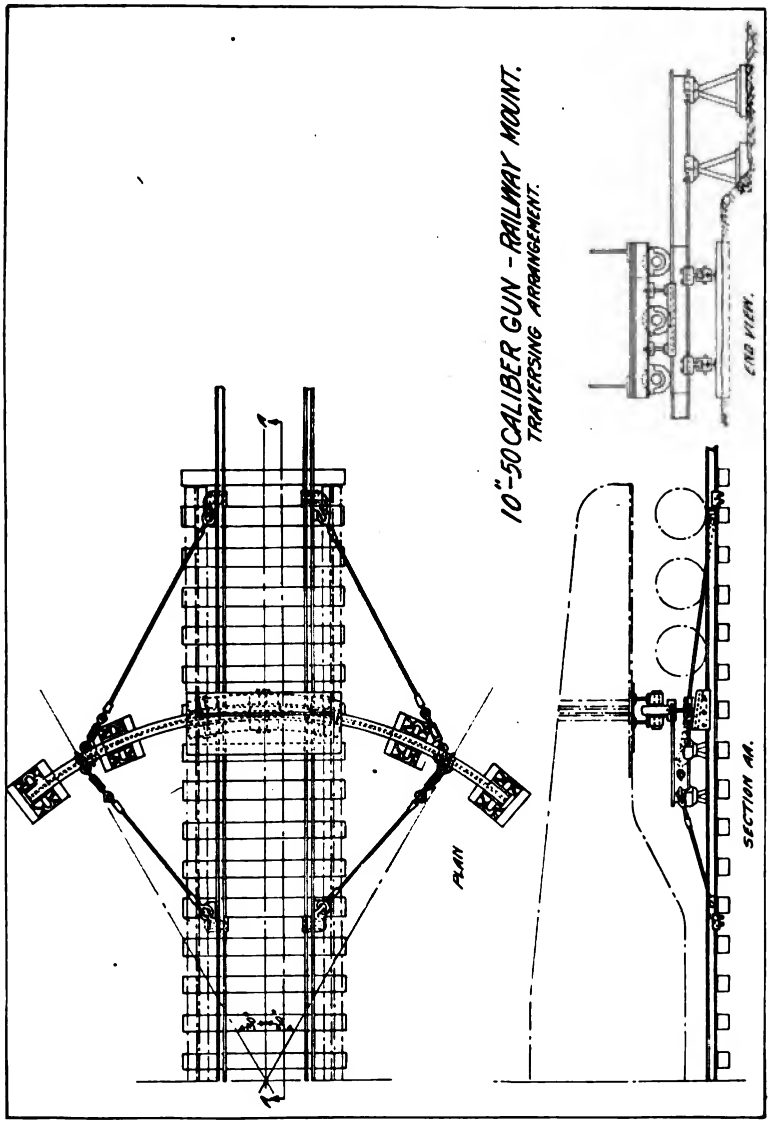

10"-50 CAL. GUN RAILWAY MOUNT.
TRUCK TRAVERSING MECHANISM
SECTION-A-B-C-D.
SYM. ABT ℄S
TRAVEL
23.5
12.
A
B
C
D

PLATE 447



10"-50 CAL. GUN RAILWAY MOUNT
TRUCK TRAVERSING MECHANISM-GEARING.

PLATE 448



10"-50 CALIBER GUN - RAILWAY MOUNT.
TRAVERSING ARRANGEMENT.

SECTION 5.

PROCEDURE IN PREPARING FOR ACTION IN LAND WARFARE.

489. In brief and in effect the procedure in preparing batteries or groups of railway artillery for action is as follows:

490. The commander of the heavy artillery receives instructions to operate on a certain group of targets in any of the sectors covered by the various armies. (This of course is based on the assumption that all the heavy artillery is available for use in any of the armies.) In the event that the heavy artillery be divided into units, a unit being allowed to each army, then the commander of the heavy artillery assigned to any given army will receive his instructions from the commander of that army.

491. The targets in the group assigned may be any of the great variety noted under the heading, "Scope of utility of railway artillery." The significant point is that they are always of the type that may be termed "fixed," in the sense that they can not be moved, or are not likely to be moved, in a short time. This makes it possible to prepare for an action in a thorough and accurate manner, and with comparative deliberation. As given in the instructions to the heavy-artillery commander, the targets are in terms of coordinates with reference to the adopted system of quadrillage. When given in such coordinates they may be readily located on any military map and the necessary firing positions selected and prepared.

492. The orders mentioned above are transmitted to the artillery officer, likely a colonel, directly in charge in the sector concerned, who, after consideration of the characteristics of the targets and the probable operating conditions, decides upon the type of artillery required, and places a request with headquarters that a certain number of groups of railway artillery of the desired caliber be ordered to report in that sector for service. The staff of this officer further carries out the work of reconnaissance, selecting the firing position, terrestrial observation posts, and parking stations for the troop trains. The orienteur officer in charge attached to the staff proceeds with the work of preparing the necessary data for laying out the epi curves, etc.

493. Upon receipt of orders from the railway artillery headquarters the group commanders proceed with their troop trains to the sector designated and report to the officer in charge. The troop

trains are parked in prearranged places and the personnel of the various batteries at once proceed with the work of laying all necessary telephone lines, constructing epis, dugouts, etc. When all preparations to the minutest details have been completed, the group commander orders the portion of his personnel still at the artillery camp to proceed to the front with the guns. Each gun, with its attendant ammunition cars, is provided with its own locomotive. It is desirable always to have the guns arrive during the night and placed on the firing positions so that firing may begin as soon as it is light enough for satisfactory observation. This observation may be either from terrestrial posts or from the air; if terrestrial, it is desired to have three posts. It is desired to have the observation handled by airplanes, if at all possible, inasmuch as they are able to make their observations approximately over the targets.

494. If necessary or desirable, the guns may remain in one position for several days, since it may take the enemy four or five days or even longer to locate them and place artillery of sufficient range to return fire. Generally it is not necessary to remain in one position very long. In one of the engagements in which the Americans, operating 320-millimeter howitzers, were engaged, one battery fired 11 shots and the other 45 shots. The targets were demolished and the battery moved out at night and returned to camp about 30 miles behind the lines. They remained in camp until needed at the front again for similar service.

495. The understanding that at first prevailed in the Ordnance Department that the various units of railway artillery would be kept in the field, as the term is used with reference to light artillery, proved erroneous. This artillery may occasionally be idle for months and when needed it may be for only a few days, after which it is moved back to the permanent camp. Incidentally, the shops for the maintenance of this artillery are likewise located in the permanent camp.

496. Construction.—As indicated in the preceding, considerable construction of various kinds is necessary in preparation for the use of railway artillery. This is described and specified very completely in the instructions for "Trackwork for Heavy Artillery," issued by the French Army. This manual is so good a treatise on the subject that it is quoted entire at the close of this section.

497. Camouflage.—The subject of camouflage is too broad to be more than touched upon here, but it will be outlined by indicating first the means developed for locating batteries, and on the other hand, the steps taken to defeat these means and hide the positions. In general, camouflage is of less importance, relatively, on railway artillery than on the lighter pieces.

498. Gun positions are located by:
Ordinary observation from—
Advance posts.
Balloons.
Airplanes.
Aerial photography.
Ranging by flash of guns.
Ranging by sound of guns.
Ranging by earth vibrations from fire.

It is understood that the French have learned, through captured documents, that the Germans were, in many cases, able to obtain almost complete information as to French battery locations by these means. The French, on the other hand, found when the Germans were driven back in certain regions, that the German batteries they had previously located by these methods, were correctly located, and represented in one instance 27 out of 30 of the batteries in the region studied.

499. The chief scheme used to camouflage railway mounts and positions are, first, and most effective, the choice of a protected position, in a wood or a ravine. Next, the careful concealment of all approaching tracks and all preparations. Then the use of painted paulins, tree branches and raffia nets, plates 449 and 451, as well as the camouflage painting of the mount itself, plate 174. Perhaps one of the most effective schemes was the interchange of gun positions and, of course, as previously brought out, the removal of the railway mount before suitable counterbattery fire could be brought into play.

500. In view of the great accuracy of the various locating methods successful concealment for long periods is almost impossible, and more reliance is to be placed on delivering the necessary shots and then getting away rapidly.

501. The most elaborate known attempt at concealment is the emplacement installed at Pont-a-Mousson between Nancy and Metz, plates 452 to 456. The concrete roof is about 2 meters thick with several meters of earth above. The gun was fired through a hole in the roof, as can be seen from the photograph. There was never any indication that the Germans ever located this battery, though their observation planes were seen above it while the gun was firing on a bridge just west of Metz on the first two days of the St. Mihiel offensive.

502. In another instance, a railway mount was located in the bottom of a very steep and wooded valley, and fired through a tunnel dug through the hill in front of it. This position was never located by the Germans so far as is known.

PLATE 449

CAMOUFLAGE OF RAILWAY MOUNTS WITH TREE BRANCHES.

PLATE 450

CAMOUFLAGE OF RAILWAY MOUNTS WITH TREE BRANCHES.

PLATE 451

340-MM. FRENCH GUN CAMOUFLAGED WITH RAFFIA NETS (GUN OPERATED BY AMERICAN PERSONNEL).

PLATE 452

CAMOUFLAGED ENTRANCE TO EMPLACEMENT FOR 340-MM. FRENCH GUN (CONSTRUCTED BY AMERICANS).

PLATE 453

CAMOUFLAGED ENTRANCE TO EMPLACEMENT FOR 340-MM. FRENCH GUN (CONSTRUCTED BY AMERICANS).

PLATE 454

ENTRANCE TO CONCRETE SHELTER TO 340-MM. FRENCH GUN (CONSTRUCTED BY AMERICANS).

PLATE 455

INTERIOR OF CONCRETE EMPLACEMENT FOR 340-MM. FRENCH GUN (CONSTRUCTED BY AMERICANS).

PLATE 456

INTERIOR OF CONCRETE EMPLACEMENT FOR 340-MM. FRENCH GUN (LOOKING TOWARD THE ENTRANCE).

TRACK WORK FOR HEAVY ARTILLERY.

503. The material which follows on "The study and locating of track," "Track construction," "Placing of firing track," etc., has been extracted almost verbatim from a translation of a French pamphlet entitled "Manual of the Course for Student Officers,"(36). This manual was prepared by the French Service for the instruction of officers assigned to their Railway Artillery Camp at Mailly, France. The translation was made by Capts. C. L. Nelson and A. N. Clark, Engineers, U. S. R., and was edited by Maj. Orville Benson.

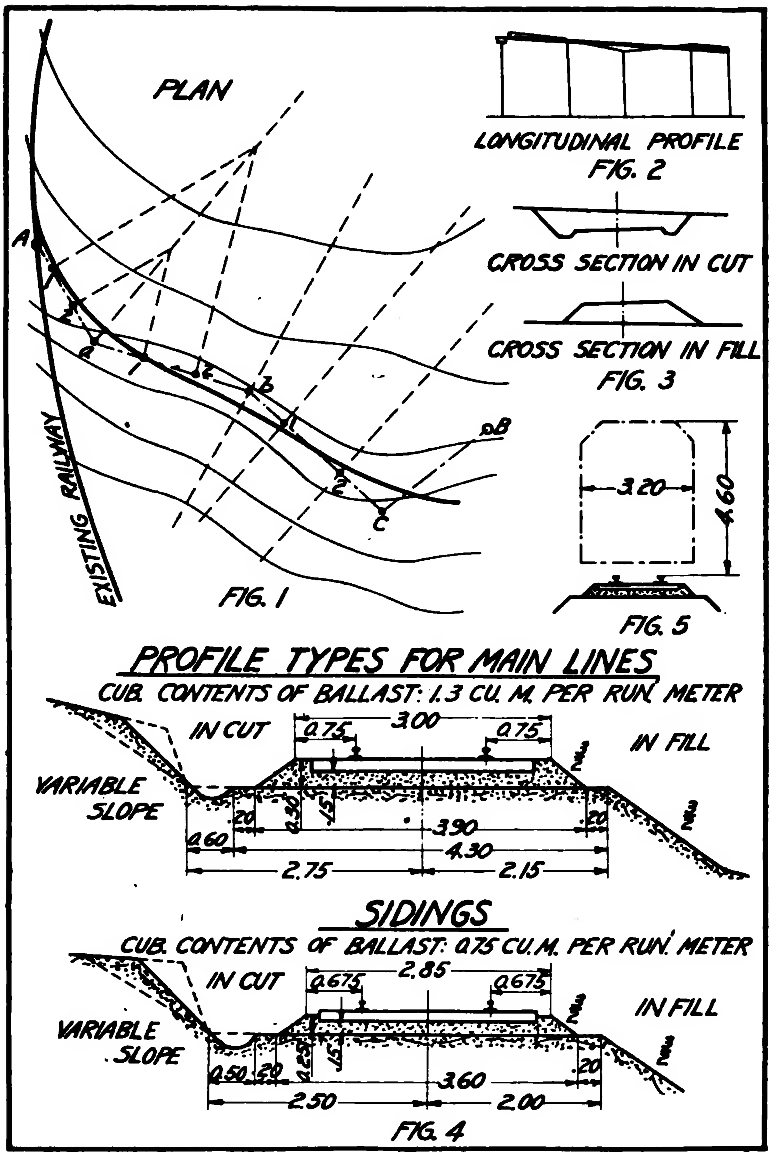
504. STUDY AND LOCATING OF TRACK.—The studies and the locating of railway tracks are made by topographic parties of certain regiments of the Corps of Engineers, or of the Standard Track Construction Batteries, who are part of the Railway Artillery Reserve.

505. The beginning and end of a line are always indicated approximately by the authority that orders the studies. After making a study on the topographic map, the chief of the party makes a reconnaissance on the ground, covering the zone of the eventual construction. This reconnaissance will reveal to him the points of necessary passage, the points favorable for the departure A, and of arrival B, the obstacles to be avoided, the parts defiladed from the view of the enemy, the camouflage which will be necessary, and permits the determination of the strip of land on which the location is possible.

506. In default of a good topographic map, it is necessary to run a grade line on the ground, to make sure that the maximum grade is not exceeded. The topographic party then proceeds to survey the aforesaid strip of land. An experienced operator runs a preliminary traverse line there, formed by a series of straight alignments, of which the extremities are indicated on the ground by stakes. These stakes and alignments are chained (Aa, ab, bc, cB) and angles A, a, b, c, figure 1, plate 457, are measured with a transit, beginning with A of the traverse. These measures allow the making of a map of the traverse which is plotted on a scale of 1/2,000 or 1/5,000. On this traverse numbered stakes are also placed at all points (1, 2) where there is a break in the slope. A level line is then run over all the points, A, 1, 2, a, b, c, B. At all these stakes a cross profile is surveyed reaching 30 to 40 meters to each side, in the same manner that the longitudinal profile was made.

507. All of the lines of the traverse and the traverse profiles (cross sections) are drawn on a plate. In this way one has the position and elevation of all of the essential points of the strip of terrain; it is easy to draw the contours on the plate. Another more rapid method is to take stadia shots directly to the essential points of the terrain from instrument stations placed successively at stations A, a, b, etc., of the traverse. On this contour map it becomes possible

PLATE 457



PLAN
A
B
C
a
b
c
1
2
EXISTING RAILWAY
FIG. 1
LONGITUDINAL PROFILE
FIG. 2
CROSS SECTION IN CUT
CROSS SECTION IN FILL
FIG. 3
3.20
4.60
FIG. 5
PROFILE TYPES FOR MAIN LINES
CUB. CONTENTS OF BALLAST: 1.3 CU. M. PER RUN. METER
IN CUT
IN FILL
VARIABLE SLOPE
0.75
3.00
0.75
0.30
.15
.20
0.60
3.90
4.30
2.75
2.15
SIDINGS
CUB. CONTENTS OF BALLAST: 0.75 CU. M. PER RUN. METER
IN CUT
IN FILL
VARIABLE SLOPE
0.675
2.85
0.675
0.25
.15
0.50
.20
3.60
2.50
2.00
FIG. 4

to study a line answering all the technical conditions imposed, which will be discussed in detail later. This line, drawn in a heavy or red line on the map, permits the plotting of the longitudinal profile, in which the distances between different points of the terrain appear as abscissæ and their elevation as ordinates, figure 2, plate 457. On this longitudinal profile one may draw the red line or profile of the track by a series of grades joining the track of departure with the objective without ever exceeding the maximum grade.

508. When the red line passes underneath the black line representing the terrain the track is in cut; when the red line is above the black line the track is on fill, figure 3, plate 457. The difference in elevation between each point of these two lines of the profile gives the height of the road bed above or its depth below the natural surface.

509. In taking account of the width of the road bed and its emplacement one may, in utilizing only the longitudinal profile, compute the volume of cut and fill necessary, and accordingly determine the number of days' work. When the project is approved the line is located on the ground; that is, it is staked out.

510. Staking.—The numbered stakes of the preliminary survey are useful in laying out on the ground the line adopted, the distances from the line to these stakes being scaled from the map.

511. Center Stakes.—The stakes are placed at the points of tangency of the curve with the tangents. In the French Railway Artillery Engineers' Service, these stakes are painted white and carry the letter "T" with a number in order; intermediate red stakes, of which the numbers are of the same series as the preceding ones, are placed every 50 meters, on tangents, and every 25 meters on curves. A tack is driven in the stake at the center of the track.

512. Elevation Stakes.—These stakes are set in such a manner that the head has the elevation of the top of rail. They are placed at the side of the track, about 2½ meters from the rail. Breaks in grade are painted in yellow and marked "C. P.," with a serial number on stakes. Intermediate stakes of the same color every 50 meters are numbered in a series distinct from that of the line stakes.

513. Specifications of Standard Track.—Minimum radius of curves, 150 meters; tangents to be inserted between reverse curves, 25 meters; maximum grade on tangents and on curves above 150 meters radius, 20 millimeters per meter, or 2 per cent. Reverse grades should be joined by a vertical curve of 1,000 meters radius. Gauge, distance between the inside of the heads of the rails. The gauge used for artillery is slightly wider than for standard track work, e. g., tangents and curves over 150 meters radius (4 feet, 8.875 inches), 1.445 meters; curves of less than 150 meters radius (4 feet, 9.312 inches), 1.445 meters. Spacing, C to C, of ties, 0.80 meters;

width of subgrade, 4 to 5 meters. The clearance required for rolling stock is given by sketch, figure 5, plate 457. The rails ought to be at least 1 meter from any obstacle, and it is necessary to increase this distance on curves to allow for leaning and the cutting in of long cars. A detailed discussion of clearances for American railways as well as French is given in paragraphs 664 to 688.

514. Earthwork.—The study of projects ought to be conducted in such a manner as to make necessary the least possible amount of earthwork. The execution of earthwork may be done, either by the method of "borrow and deposit," in which necessary earth is taken from borrow pits along the side and excess material is thrown back over the sides of the cuts; or by the method of "transports," in which the earth is carried from the cuts to make up the fills. While the earthwork is in progress care is necessary that the grade stakes be not disturbed.

515. The depth to which it is necessary to go to reach the subgrade may be indicated to the excavators in a striking manner as follows: (*a*) In cut, a hole, half a meter square, is made at the side of each stake with the bottom at the level at the subgrade; or, the depth to which it is necessary to descend is written on the head of the stake. (*b*) In fill, the red line of the fills is represented in profile with pickets of the proper length. In fills the height is increased 10 per cent to allow for settling. The earthwork is controlled with a set of "nivellets en bois."

516. Side Slopes of Cut and Fill.—In ordinary soil the slope of a cut varies between 1 to 2 in height to 1 on the base. In chalk one may adopt 5 in height to 1 on the base. The slope of fill is 2 in height to 3 on the base; sometimes this is reduced to 1 to 1 to reduce the base, figure 1, plate 478.

517. Amount of Earthwork per Excavator per Day.—A man ought to dig and load into a wheelbarrow, or dig and throw with one toss of the shovel, from 2 to 4 cubic meters of earth in cut in a 10-hour day. In firm soil, e. g., chalk, or moist soil, i. e., clay, the production may fall to from 1 to 3 cubic meters. With a shovel a man can load or unload from 8 to 10 cubic meters of soil, gravel, or ballast per day.

TRACK CONSTRUCTION.

518. Material.—In France two types of track have been adopted; they are distinguished by the form of the rail and the method of attachment to the ties. These are: (1) Voie Vignole or T rail; the tie is notched to provide a seat in which the flange of the rail rests; the rail is fastened to the tie by two or three screw spikes, figure 2, plate 478. (2) Voie & Coussinets (chair track); the rail has a nearly symmetrical section and is held by a wedge in the chair, which is fastened to the tie by screw spikes, figure 3, plate 458. The rails

PLATE 458

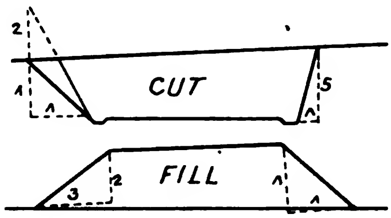


FIG. 1

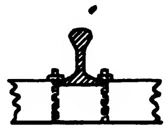


FIG. 2

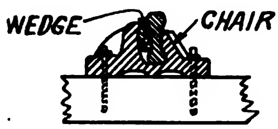


FIG. 3

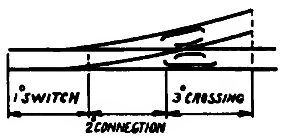


FIG. 4

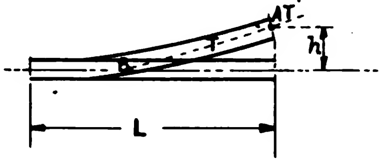


FIG. 5'

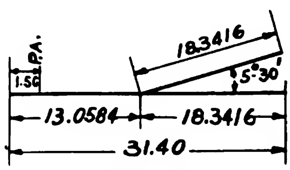


FIG. 6

PROFILES, RAIL SECTIONS, AND SWITCHES.

should be inclined 1 in 20 toward the axis of the track so that the bearing surface of the head of the rail and the wheel tread may be parallel; in the first type it is the seating in the tie that gives the inclination, and in the second it is the shape of the chair.

519. SUPERELEVATION.—To facilitate traveling on curves of short radius an inclination is given to the track by raising the outer rail. For railway artillery rolling stock, which travels at a slow speed, a difference of elevation of from 3 to 5 centimeters between the two rails is sufficient for curves of a radius of from 150 to 125 meters. To bring the two rails on tangents to the same level the difference is eased off along a length of about 12 meters beginning at the point of tangency.

520. EXPANSION AND JOINTS.—A small space is left between the rails when they are laid to allow for the expansion of the metal. This interval, which is a function of the length of the rail, should be very large in summer and very small in winter. In France a variation of 0.6 millimeters per meter is allowed between the two extremes in temperature.

521. PLAN OF PLACING OR LAYING TIES.—The spacing between ties may vary between 0.5 and 0.85 meters. In general the following numbers for rails of different lengths are adopted:

Length of rail.	Ties per rail.
5.50 to 6 meters	7
8 meters	10
11 meters	14
12 meters	16

522. PLAN OF PLACING THE RAILS.—In standard gauge military track laying the rail joints should be exactly opposite each other. Since the lengths of the radii of the inner and outer rails on curves differ to the extent of the gauge of the track, it is necessary to supply rails of different lengths to obtain this result. For quick laying in a campaign the rails are usually supplied in equal lengths, and the following principles are then adopted:

(1) T rails: Little attention is paid to the locating of the joints. They may fall on a tie, since this does not prevent the rails from being spliced and screwed to the ties; or, the joints may come between the ties. In this latter case the ties at the joint should be a little closer together to lessen the suspension of the rails.

(2) Chair rails: With rails of this type it is necessary, of course, that the joints come between the ties, and the requirements, especially on curves, will be a little more severe.

523. In laying rails of either type the following principles are followed with reference to the relative position of opposite rails: (*a*) On long tangents the joints should be even. (*b*) On curves the joints should be staggered with an overlap of about half a rail length.

(This necessitates starting with half a rail length at the point of tangency.) (*c*) On crooked lines or wherever tangents are not predominant, staggered joints should be used throughout the entire length.

TRACK LAYING.

524. Before beginning the track laying it is necessary to check for the stakes that may have been disturbed during the excavating. These stakes will serve as guides for distributing the ties and the rails, and after the ballasting has been completed they will serve as guides for the exact placing of the track. Following are brief rules for the laying and assembling of the track components:

(*a*) Ties: The ties are properly spaced by means of a gauge and are aligned approximately through the use of the rail notches as guides.

(*b*) Rails: As noted in the preceding paragraphs, spaces should be left at the joints for expansion, and care should be exercised to avoid any considerable displacing of the ties.

(*c*) Joining of the rails: The connecting or fish plates are placed at the rail joints and bolted tight.

(*d*) Adjustment of ties: After the rails are bolted together the exact positions of the ties may be marked off on them with chalk, and the ties adjusted to this marking by hand or with bars.

(*e*) Spiking or wedging: As soon as the ties are adjusted the rails may be spiked to them, using a gauge to keep the rails the proper distance from each other, if T rails are being used. If rail chairs are provided, these chairs will have been previously spiked to the ties at proper distances apart and the rails need only be wedged into them.

(*f*) Firing track: For this section of a track T rails of a heavy weight and from 11 to 12 meters in length are always used. No particular attention need be paid to the locating of the joints. Particular attention must be paid, however, to the locating of the ties with respect to the holes in the structural steel sliding beams.

525. Turnouts.—A turnout is composed of three parts. These are (1) A switch, which is the operating section; (2) a junction, which carries two ordinary tracks; and (3) a crossing with a frog or guard rails. A crossing may be defined in two ways—that is, either by the angle between the two tracks which it cuts, for example, 5 degrees and 30 minutes, 7 degrees and 30 minutes, which are angles in use on the Est Railway, or by the tangent of the angle between the two axes.

526. Study of Turnouts.—In preparing for the placing of a switch, the type having been determined, it is necessary to know the follow-

ing: (1) The total length of the turnout, L, and (2) the position of the tangent of the turnout, TT, which is defined by the position of the point B, with intersection of the axes, with reference to one end of the switch, and by the angle between the two axes, figure 5, plate 478. Figure 6, plate 458, illustrates the standard 5-degree 30-minute, model 1909, 45-kilogram rail switches in use on the Est Railway.

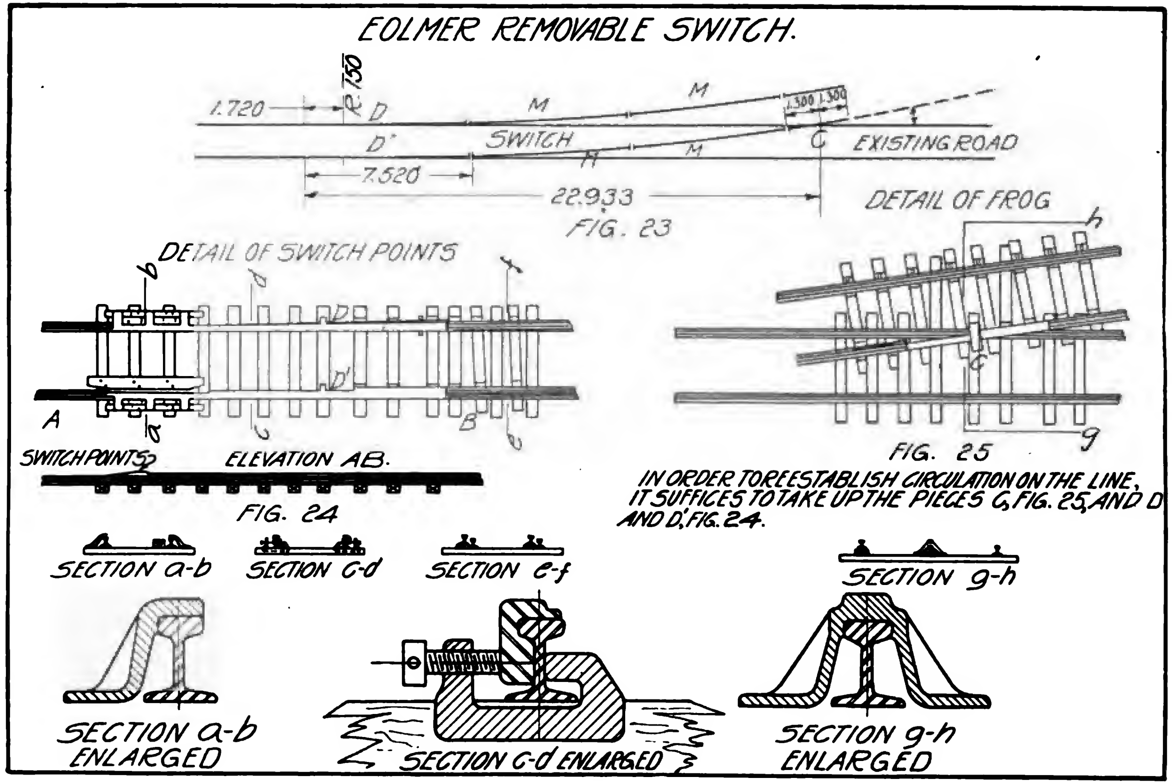
527. BALLASTING AND ADJUSTING.—Before ballasting, grade stakes are set regularly at intervals of 25 meters as well as along or inside the track at changes in grade. The top of a stake gives the elevation of the rail (inside rail on curves). The quantities of ballast per meter of track are: (1) Through tracks, 0.60 cubic meters to 0.75 cubic meters, according to the nature of the terrain; (2) firing tracks, 1.200 cubic meters.

528. The straightening, adjusting and tamping is handled successively, and with repeated corrections until the desired regularity both in plan and profile is obtained. The raising of the track includes: (1) The raising and bringing to grade of points at the grade stakes, and (2) the raising and bringing to grade of all points between the grade stakes. In this second raising three little blocks of equal heights may be placed at the points first raised and the point being raised for convenience in sighting. The track having been raised by means of screw jacks or levers, the ballast is gradually filled in and tamped under the ties with tamping picks or bars. The tamping should be energetic under the rails and to a distance of from 30 to 35 centimeters on either side; under the middle of the tie it should be very gentle. The straightening is handled ordinarily by a gang of about a dozen men using large bars. The track is lined up with the line stakes by measurement and for final and fine adjustment by sighting with the eye.

529. EOLMER SWITCH.—The installation of the standard type of switch generally requires two days with a gang of 20 trained men and necessitates the complete cutting of the main line for a distance of about 30 meters for several hours. The Eolmer is a removable switch which can be placed in a few hours at any point whatsoever of a track in service and without taking up the rails. To clear the main line for traffic, it is necessary to take up only three pieces of the switch, which can be done in about 10 minutes.

530. The whole of the Eolmer switch is represented in figure 1, plate 459. It is shown here turned to the left. The switch points, b and D, fit to the main line rails on the top instead of along the side. The tops of the switch points are shaped to a gentle grade and raise the wheels gradually until the flanges are above the rails of the main track. At this point the wheels may follow the switch and they definitely leave the main line when the one wheel crosses the frog at C, figure 3, plate 459. Figure 2 shows how the points are attached

PLATE 459


FOLMER REMOVABLE SWITCH.
R 750
1.720
D
D'
M
M
SWITCH
M
1.300 1.300
C
EXISTING ROAD
7.520
22.933
FIG. 23
DETAIL OF FROG
DETAIL OF SWITCH POINTS
A
B
SWITCH POINTS
ELEVATION AB.
FIG. 24
FIG. 25
IN ORDER TO REESTABLISH CIRCULATION ON THE LINE, IT SUFFICES TO TAKE UP THE PIECES C, FIG. 25, AND D AND D', FIG. 24.
SECTION a-b
SECTION c-d
SECTION e-f
SECTION g-h
SECTION a-b ENLARGED
SECTION c-d ENLARGED
SECTION g-h ENLARGED

and figure 3 shows the type of frog used. It is necessary to take up only three pieces of the switch, the two points and the frog, to reestablish the main line. The pieces of rail *MM* may be left in place. Naturally the turning off of a locomotive and railway gun carriage to an epi by means of a removable switch requires care and very slow speed. It has been used, however, with perfect success and the saving in time in installation is so great as to commend its use.

531. Grade Crossings.—Crossings for the passage of wheeled vehicles are shown in section in figure 1, plate 460. On both sides of the track, slopes of well rammed earth covered with gravel or rock are made. Inside the track the space is brought to the level of the rails by well rammed gravel and earth flanked by ties or timbers placed 0.05 meters from the rails, and spiked to the ties. It is of course preferable to build up the entire space between the rails at grade crossings with timbers if they are available.

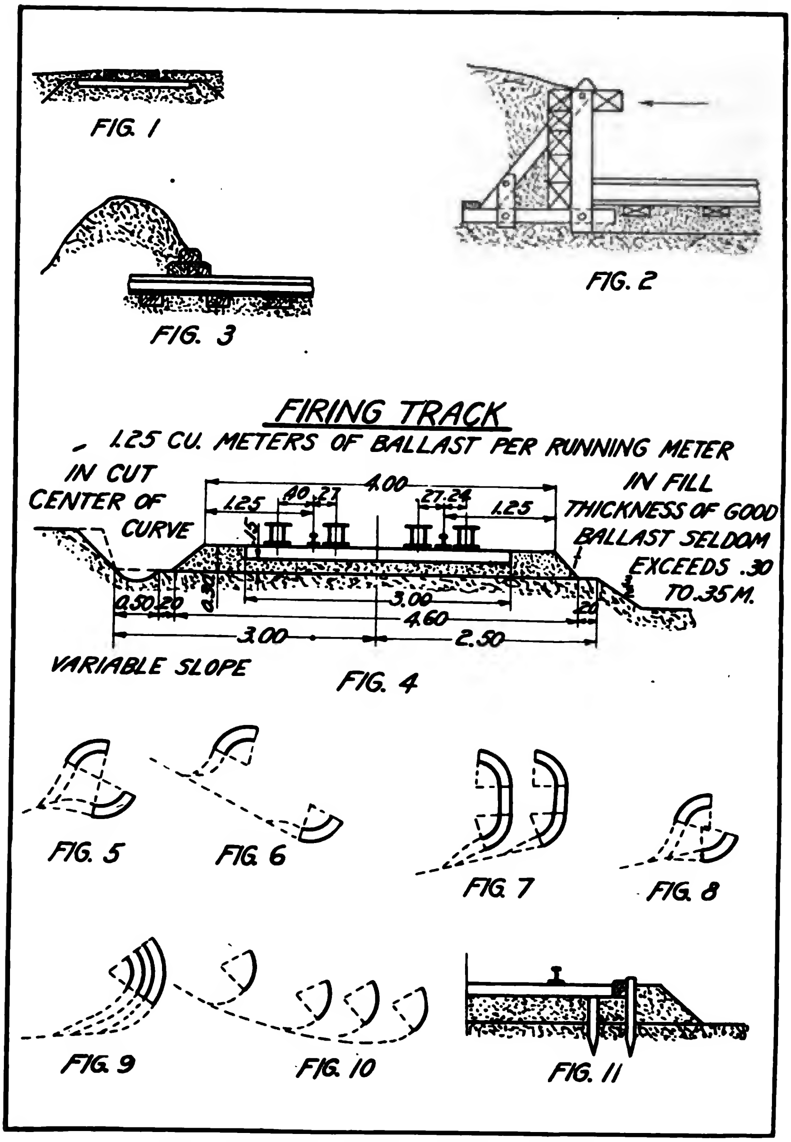
532. Buffer Stops.—At all dead ends of tracks some variety of buffer stops should be constructed. If material and time are available, an effective stop can be constructed of ties reinforced by a mound of earth as shown in figure 2, plate 460. If less time is available a stop may be constructed of several ties laid on the track and reenforced by a mound of earth, figure 3. A single tie backed up by two rail clamps of the variety used with the 19 and 24 centimeter French railway mounts is effective.

533. Reversing Triangles (Wyes).—In artillery parks or yards or in a position on the front in the vicinity of which a number of firing positions have been installed, i. e., any place where it is not practicable to provide turntables of the usual type for reversing locomotives, railway mounts, etc., reversing triangles or wyes must be provided. In yards this may be especially laid out for the purpose or on the front it may be made by connecting an existing spur with the main line by an additional curve forming a triangular inclosure or wye.

EPIS.

534. Railway mounts are operated on a specially constructed piece of track called a "firing track" (epi de tir). These tracks (epis) are constructed for two classes of gun mounts: (1) Those which are supported by firing beams (Poutrelles) at the moment of firing, so that the shock of recoil is absorbed by sliding friction along the beams; (2) those in which the shock of recoil is absorbed by hydraulic cylinders, the mount being securely clamped to the track which, in the case of the heavier guns, is reenforced to withstand the shock of firing. Epis are curved in such a way that guns can be oriented, to cover the desired field of fire, by moving them along the track. The "Orienteur officer" places grade marks on the web of the outer rail of the curve as a guide for the battery commander in placing the gun.

Plate 460



CROSSINGS, TRACK ENDS, AND FIRING TRACKS

SLIDING MOUNTS (MATÉRIELS à GLISEMENT).

535. Guns mounted on sliding carriages are fired from a track called a firing track or epi, laid on the arc of a circle so as to permit the orientation of the piece to cover the field of fire selected. For firing, beams (poutrelles) are placed parallel to the rails and screwed to the ties; the jacks which relieve the wheel trucks of their load bear on these beams and provide friction for absorbing the shock of recoil.

536. Firing Beams.—The above platforms or beams are about 37.50 meters long. This length permits 8 grads (7.2 degrees) field of fire for a curve of 200 meters radius and 10 grads (9 degrees) for a 90-meters curve. They should not be fastened to the ties before the gun is ready to occupy the position to fire. They are then fastened with screws in the holes that will be mentioned in the next paragraph.

537. Firing Epi Construction.—The firing epi for each piece is a curve constructed with special T rails (45 kilograms) and chamfered ties (0.15 by 0.30 by 3 meters). Firing tracks have no super-elevation. The gauge is from 1.45 meters (4 feet 9.062 inches) for a curve of 150 meters radius to 1.455 meters (4 feet, 9.312 inches) for the smallest radius (90 meters). The special ties are not shod, but are delivered bored for track screws. They should be spaced 0.54 meters, *C* to *C*, on center line of track. Holes are provided in the ties to receive the screws for both rails and beams. To prevent ballast from getting into these holes it is well to plug them with straw or hard grease. The ends of the tie in which the distance between the holes for the rail and the beam is the greater must be laid on the inside of the curve. After the ties are laid, their proper position should be verified by running the eyes over these holes, figure 4, plate 460. Track screws of a standard type and size only should be used in these ties; nothing else that might change them or prevent their being used again should be used. At rail ends, the screws must be carefully screwed down and not driven down with a hammer.

538. Ballast.—The ties should be laid on a bed of excellent ballast, 0.15 meters (6 inches) thick, extending 1.50 meters beyond each end of the ties. The tie should be completely buried in the ballast throughout its length. The resulting bed of ballast will be 4 meters wide at the top and 4.60 meters at the bottom; this will require about 1.50 cubic meters per meter of track. The ballasting should be done with special care, the tamping being done preferably with bars.

539. Epi Limits.—An epi is usually defined by its point of beginning and the direction of its two ends, but to avoid confusion it

should always be made plain whether extreme directions refer to the desired field of fire, or to the construction of the track itself. Sufficient trackage must be provided for the auxiliary equipment, either ahead or to the rear, depending on its relation to the working of the gun; the length of the curve must exceed that corresponding to the field of fire prescribed in order to provide for corrections in aiming, usually an equivalent of 10 degrees are added to each end, making a total increase of 20 degrees in the curve.

540. Epi Specifications.—In general the firing epi has a uniform curvature; but in a very exceptional case the terrain may make it necessary to adopt an irregular curve; in such case the radius must never be less than 90 meters (approximately 300 feet), and the extreme direction must be maintained in such a manner that the tangents to the curve will sweep the entire field of fire progressively as the gun advances along the epi. In general also, the epi should be level, but to facilitate its adaptation to the terrain, a grade not exceeding 5 millimeters per meter (5 per cent) may be used. In every case the epi should be constructed in cut, so as to assure a solid platform for firing; exception may be made for those sections of the epi occupied only by the end trucks in extreme fire since they would never receive the shock of recoil. If fill is unavoidable, as for instance in crossing a ditch or depressed road, the fill must be made with good ballast well rammed, with no voids whatever that could cause settlement. When the cutting becomes deep it is well to have its sides made in steps to facilitate the get-away of personnel at the moment of firing.

541. Battery Epis.—In whatever way the epis of a battery are arranged, sufficient space (at least 50 meters) must be allowed that there shall be no danger that one shall suffer from the blast of the other. When the two epis are near each other, they should be concentric so as to insure a common direction of fire. Usually two epis are constructed together with a common center, having respective radii of 90 and 140 meters.

542. Group Epis.—With a group consisting of four pieces, the "group epi" may consist of four epis together made up of two "battery epis" in some form, bearing in mind the "blast" mentioned in connection with "battery epis." Parallelism of four pieces may be secured by arranging the epis in a forceps form, figure 5, plate 460. This form may be approximated by separating the curve centers, figures 6, 7, and 8. Other forms necessitated by the terrain are, the "palm," consisting of four epis with a common center, figure 9, or of four epis curving the same way, but having different centers, figure 10. A gun must always be at least 50 meters from the field of fire of neighboring pieces.

MOUNTS WITH HYDRAULIC RECOIL (MATÉRIELS à FREIN).

543. Among the gun carriages provided with hydraulic recoil, some of the lighter ones (6 to 10 inches), may fire from any track on the condition that the track be reenforced whenever it is used for firing. The material is not dismounted. The stability of the carriage is secured generally by the use of clamps which fasten the carriage to the rails and by hinged outriggers provided with jack-screws supported by footings placed on the ground. The stability is increased by adding several well-tamped ties under the rails, and by placing, under the ends of the ties, on the side of the recoil, longitudinal ties held in place by several stakes sunk deeply into the ground. If the ground is too yielding, long stakes may be sunk into the ground between the ties, on the heads of which supplementary ties are placed. In addition longitudinal ties are laid against the ends of the ties and are held in place by stakes, figure 11, plate 460. A thorough tamping under the ties concerned is indispensable.

544. The carriages for the larger guns (12 to 16 inches) require the construction, under the firing track, of very strong platforms sunk into the ground, of which the details differ according to the caliber and the design of the mount. The installations require from one-half to four days, likewise according to the caliber and design.

CAMOUFLAGE OF RAILWAYS. (37)

545. The camouflage of railways, especially firing positions, to conceal them from the view of airplanes and above all to keep them from appearing on photographs is very difficult. The Germans, who were very attentive to this question were, in general, not able to conceal their tracks and firing positions except in the woods.

546. At the beginning of the appearance of the railway artillery at the front, little attention was paid to the camouflaging of the tracks. The mobility of this artillery, the great distance between the pieces and its distance from the lines (nearly always more than 5 kilometers) have been its best protection. It has remained almost unharmed, while according to the maps found on prisoners, it is established that the curved epis of the Somme were nearly all known to the enemy, and most of the firing took place in view of the "drachens" (observation balloons). It is nevertheless of interest to conceal preparations for attack from the enemy and to hide from him the cannon in action to avoid counter-battery fire.

547. ACCESS TRACKS.—It has been recognized as advantageous to conceal the switch and the first 200 meters of the turnout to a firing position under tents of cloth and fireproof raffia. It is desirable to place the tracks in a woods, disturbing the trees as little as possible, and bringing the branches together over the track. Tracks may be

laid along the edge of woods to conceal at least partially the new earthwork, or on beaten roads, thereby avoiding earthwork which easily attracts attention. The rails and ties may be masked under ballast or cloth and deceptive road ends may be made at a noticeable point such as quarry, a wood, a farm, or another road by a false branch made up entirely of painted cloth. The true entrance should be concealed under cover of the woods, making a turnout and a false entrance further along.

548. Firing Epis.—Experience has shown that one need not consider the masking in a group of curved epis of any but the directing gun ("Directrice"), by concealing the switches and completing the curves by false track. Complete camouflage of the whole work would be long and of little use. It will be well to make false epis in the neighborhood by means of a simple turning over of the earth with a plow, by simulating pieces covered with tarpaulin, and by placing on the true epis false shell holes to make it appear that the access to or the use of them is impossible.

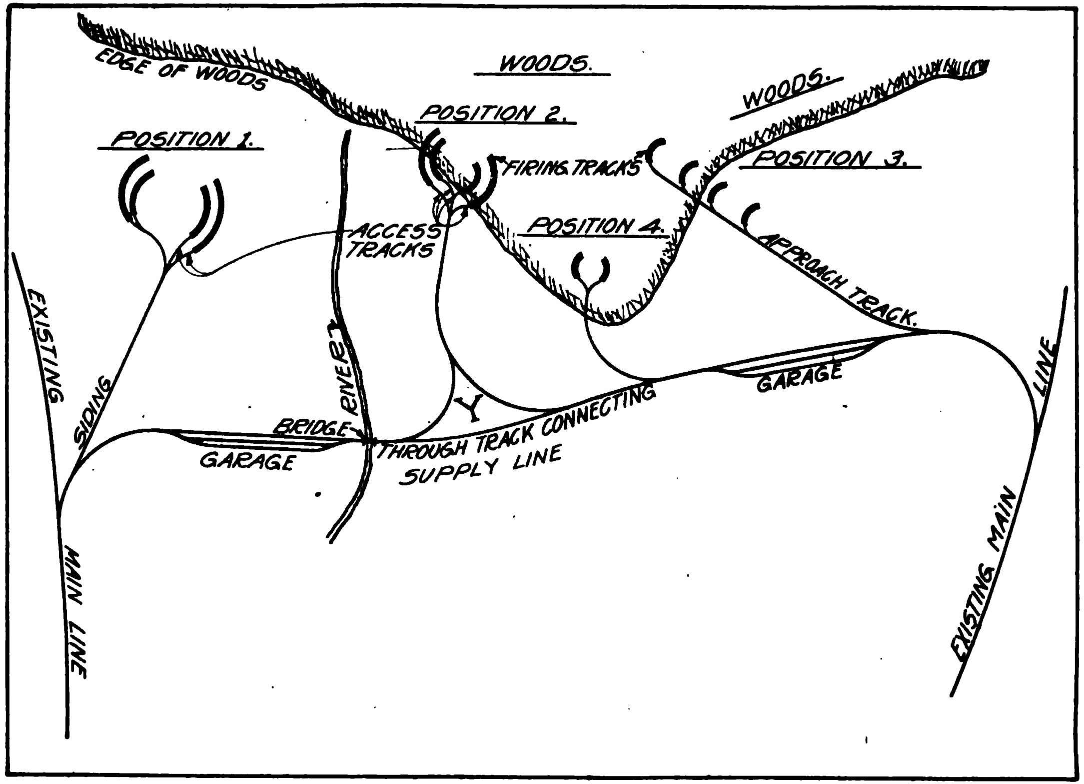
549. Single epis, curved or straight, are much easier to camouflage. First, one can often place them in woods or ravines; when they are very short, as in the case of the howitzers, it is even possible to cover them completely with cloth or raffia. It is desirable to avoid the use of geometrical curves in the access tracks. In open country these epis can be prolonged by a false road or a false track to a natural point of attraction, as another track or road, or to a quarry or a town; if one doesn't succeed in concealing the railroad, one has at least a chance for hiding the epi itself, and that is what is most important.

GARAGES.

550. Components.—Each garage for heavy railway artillery comprises chiefly, a line track, a passing track paralleling the line track throughout the length of the garage, and which serves as a maneuvering track, some storage tracks reserved either for firing trains or for personnel trains, and branches on the maneuvering track, plate 461. At some place in the complete system there must be a Y track for turning. In certain garages, the tracks for personnel trains are not ballasted. This economical plan presents no difficulties provided the personnel trains only are admitted to them. As far as possible, no tracks for firing trains should have dead ends, in order that they may not be blocked in. Garages are established at suitable points where the ground is level, near a road to facilitate supply renewals and where water may be had. Usually two or four groups can be united.

551. Length of Tracks.—The lengths adopted for the storage tracks vary according to the equipment. For a group of four 32-centimeter guns there is generally allowed 350 meters for the firing

PLATE 461



SCHEME OF DEVELOPMENT OF RAILWAY ARTILLERY.

trains and 350 meters for the personnel trains. The radius of 150 meters has been adopted as the most suitable for curves on garage tracks; for sharper curves over which guns are to be moved superelevation must be given.

552. Water.—If the water supply points be near, the locomotives go there, separately according to a rotation regulated by the commanding officer of the camp. If there is a place to fill water cars, or if the source of water supply is distant, provision is made for one or several water trains, which circulate as conditions require, to supply all groups which occupy the garage. In case the source is distant, locomotives supply themselves at the water cars of the group.

553. Fuel Depots.—It will be convenient to arrange, at a suitable storage point, a small depot, independent of the fuel supply which the groups maintain in the supply cars, where all the groups may replenish their supply.

554. Miscellaneous Installations.—It is advisable to build a ballasted road to accommodate automobile trucks, for supply replenishment, between the nearest main road and the garage. In each garage, there should be built a hut or switchman's shanty for the yardmaster and a hut to serve as a telephone central for connecting the units stationed at the garage. The telephone lines will connect the yardmaster with the "chef de la gare" of the junction of the railway artillery line with the main line and with the post of the switchman stationed at the exits of the garage. It is necessary, moreover, to provide for each garage such operating equipment as red and green flags, green, red and white lanterns, lights for the yardmaster's hut, and materials for maintenance of switches. The maintenance of the garage trackage is the duty of the permanent personnel of the garage, aided if necessary by auxiliaries furnished by the various groups. A small supply depot should be established for this purpose.

MAINTENANCE OF TRACKS.

555. Requirements of Good Tracks.—A good track must be regular in alignment and profile without kinks or sharp bends. The inspector satisfies himself on these points by going over the line and verifying the regularity of alignment, straight or curved. To verify the profile by a glance of the eye, place the eye from time to time close to the rails, looking along the track as far as possible. The ends of the rails must not touch each other, a space between them sufficient for expansion being required. Each joint must be formed with two splice-plates fastened with four bolts (for heavy work six bolts are used). Flange rails must be fastened to each tie with at least two screws; double-headed rails must all be wedged into the bearings by the wedges of wood or iron. Every bent or broken rail makes

traffic dangerous, and must be replaced. Loose ties (insufficiently tamped) must be made solid by tamping; broken or rotted ties which depress under the passing of trains must be replaced at once, as they cause derailments. The spacing of the ties must not exceed 80 centimeters, *C* to *C*, to avoid bending of the rails. The ballast must be porous and firm; if the base is wet or muddy it lacks resistance, and must be drained or the track will not retain its profile.

556. Dressing and Raising the Track.—Defects in the alignment are rectified by a gang of 6 or 10 men, equipped with pinch-bars or levers and directed by a gang foreman. The pinch-bars are set under each rail and the men heave together, at the command "Oh Heave!" At points which are too low it is necessary to raise the track by means of large wooden levers called handspikes or with small jacks. The jacks are set under the ties, and never under the rails. The ballast should be adjusted under the lifted ties. For correcting the track grade, three wooden leveling blocks of the same height should be used; two are set on the rails at points of correct grade and the third on the rail to be raised. The point between is at grade when the tops of the three blocks are in the same plane. The heights of the three leveling blocks should always be checked before using them.

557. Replacing and Tamping Ties.—To replace a tie it is necessary to remove some ballast, remove the screws from the tie, lift out the wedges and the cradles and withdraw the tie by means of picks. The new tie is then slipped under the rail and tamped temporarily; after placing the screws, or the cradle and wedges, if used, the tamping is completed. Four workmen are sufficient. In tamping, two men work together at the same end of a tie, piling a little ballast against each side, and forcing it under by blows of a mattock or a tamping bar.

558. Replacing the Rails.—The splice plates and a row of screws or spikes are removed along the rail if flange rails are used; the extreme splices and all the wedges are removed if double-headed rails are used. A cut of rail of equal section and length may then be set in the opening, the men being placed about a meter apart along it. Its flange will be engaged under the heads of the screws or spikes in place, or in the opening of the cradle, some space being allowed at the two ends of the rail. The splices and the screws, spikes, or wedges will then be replaced and the job finished by dressing or tamping. All screws and bolts should be greased before screwing them in.

559. Repairing a Cut Made by a Shell.—A shell of large caliber falling on a track ordinarily breaks 8 or 10 ties, and twists the rails for a distance of from 20 to 30 meters. It is necessary first to provide the ties, rails, splices, bolts, wedges, and screws estimated to be required for the repair. Laborers should be set to filling the hole,

ramming the soil in layers at the same time that the trackmen are removing the twisted rails and the ties on which they rest. As soon as the shell hole is filled the ballast can be restored and the ties and rails replaced, spliced, and spiked or wedged. The work will be finished by dressing the track for alignment and profile, and complete tamping.

560. TRACK DRAINAGE.—New drainage ditches should be made deep and old ditches kept clean. They should always be provided in cuts and on level ground to assure a flow of the water. If necessary, drains of tile, stones, or of bundles of boughs should be installed beneath the track and joining the two ditches.

561. HANDLING OF TRACK MATERIAL.—Two men can carry an ordinary tie (weight 80 kilograms). It requires three men to carry a tie with cradles attached (weight 125 kilograms). Four men are needed for firing track ties (3 meters long, 160 kilograms). Rails ordinarily weigh, double headed, 38 kilograms per meter, and flanged, 45 kilograms per meter. For the carrying of rails, an allowance of one man for each meter of length is made. Small supply depots of rails, ties, splices, etc., for possible repair work, are generally established at intervals of about 1 kilometer along military railroads. It is necessary that all officers of railway artillery be able to direct a small job of construction or repair work.

DEPLOYMENT OF RAILWAY ARTILLERY ON THE ATTACKING FRONT.

562. Railway artillery, being difficult to conceal, is ordinarily employed in the mass. In the region of attack, there are united as many positions as possible with a view to meeting various tactical situations; positions in the rear for demolition fire, advanced positions to be occupied on the days of attack, and contingent positions for pursuit, whence to support the infantry as long as possible.

563. There is constructed, parallel to the front, a supply line (voie de recade), plate 461, connected with two operating lines. This track is generally constructed by the S. C. F. (service de Chemin de Fer—equivalent to our railway engineers). From this line, which the Army uses for rationing and the transportation of munitions, there extend various branches which lead to position 1, 2, 3, etc. Near the supply line there are distributed the garages for firing trains and personnel trains, the water-supply points, etc. A single supply line may extend over 40 to 50 kilometers length along the front.

NOTE.—The French use the expression "voie de recade," here translated "supply line," to apply to the track system approximately paralleling the entire western front from Dunkirk to Belfort, and style the train that traverses it daily "The Recade."

564. The access tracks that lead to the position are sometimes 4 or 5 kilometers long; with an average of 2 kilometers to a position,

the four curved epis of a group represent a total length of from 600 to 800 meters. The equipment of an attacking front generally calls for the laying of 200 kilometers of track, taking into consideration the retention of existing trackage. The amount of earthwork involved in the construction of the access tracks and firing tracks of a group sometimes reached 8,000 to 10,000 cubic meters per position, the average being 2,000 to 3,000 cubic meters per position. The extent of trackage for railway artillery garages and ammunition dumps on the front of any army is from 15 to 20 kilometers.

565. A military laborer, who costs 5 francs per day, excavates 2 cubic meters per day and lays 4 meters of track on an average. Ordinary ties cost 15 francs each, firing track ties 25 francs, and rails 60 francs per 100 kilograms. This gives an idea of the expense of railway artillery trackage. It is necessary that the entire personnel of the railway artillery be entirely familiar with their duties, to make the best use possible of the powerful and expensive equipment that is entrusted to them.

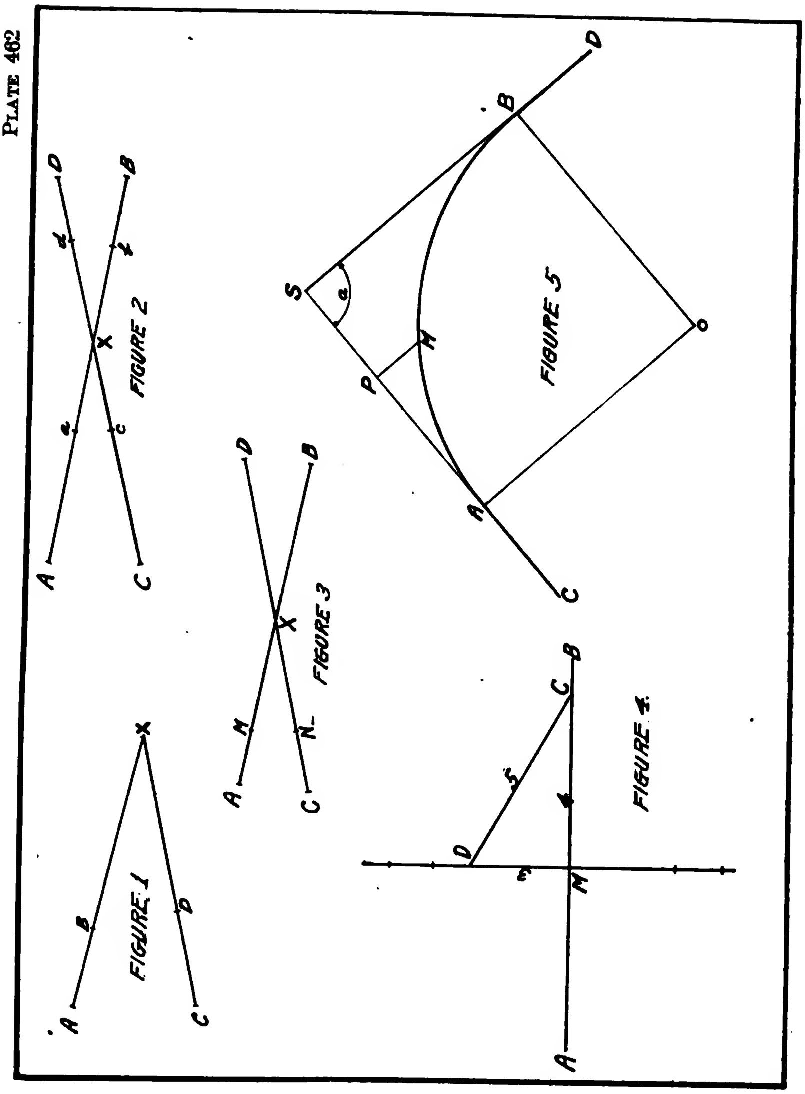
SUPPLEMENT TO TRACK LAYING.

566. To Stake Out a Straight Line Between two Fixed Points.—The chief of the party places himself 20 meters behind one of the points and sends the rodman 50 meters ahead. The rodman places and drives a stake so that its foot is in line with both fixed points. (Lining it in by eye.) He continues to place stakes at desired intervals which the chief of the party lines in from his original position as long as he can effectively do so. If the line goes through a depression, the chief may go forward and line up stakes with those already set.

567. To Find the Intersection of Two Alignments.—A rod or stake X, figure 1, plate 462, may be set at the intersection of alignments AB and CD, by placing observers at A and C or at stakes on AB and CD, respectively, who line in the rodman's pole or stake alternately until it coincides with both lines. If the rodman is using a stake, he carefully drops it and drives it in where its point strikes.

568. If the operator is alone, he stations himself at the approximate intersection and marks the spot with a stake, figure 2. He then places a second stake on AB about 10 meters from the intersection, lining it up with the first stake and A or B, as the case may be. Next a third stake is placed on AB and about 10 meters on the other side of the first stake. He then disregards the intersection stake and begins to line up the stakes a and b with A and B. From a he lines in b with B, moving b (not a) until it is in line. Then he sights from b and lines in a with A, moving a (not b) until it is in line. It may be necessary to go from a to b a number of times in

PLATE 462



METHODS OF LINE STAKING.

this procedure until the stakes are perfectly in line. Stakes *c* and *d* may then be lined in with *C* and *D* in a similar manner. The locating of *X* as the intersection of *ab* and *cd* needs no explanation.

569. To Erect a Perpendicular at a Point *M* of an Alignment Determined by Two Stakes, *A* and *B*, Without Instruments.—This solution is based on the fact that if the legs of a right triangle are 3 and 4 or any multiple of 3 and 4 units in length the hypotenuse is 5 or a similar multiple of 5 units in length. From *M* toward *B* a distance of 4 units (meters, yards, or any length marked on a stick) is measured and staked at *C*. Then a length of 3 units is measured on one string or stick and 5 on another. The 3-unit string is attached to *M* and the 5-unit string to *C*. If their ends are brought together, keeping them uniformly tight, a point *D* is located on the desired perpendicular. *MD* is the perpendicular.

570. To Measure Distance Along the Grade.—The chain is stretched on the ground. The rear chainman keeps his zero mark on the head of the starting stake, or against the pin already set. The head chainman stretches the chain and sticks the pin at the end mark. He stands on the side of the chain, the shoulders in line with the rear chainman, and head turned his way; he moves backward or forward according to the directions of the rear chainman. The arm extended indicates to which side he ought to go; the arm suddenly lowered indicates that he is to stake the pin.

571. After sticking the pin the chainman ahead moves on, keeping the chain stretched. When the rear chainman finds the pin previously set, he holds his zero mark and directs the head chainman, waving him on when the pin is stuck. When the head chainman is out of pins, he will still continue to stretch the chain its full length from the last pin set, then leaving his handle on the ground, he comes back to the rear chainman, from whose hands he receives anew the 10 pins, which he is careful to count while returning to his place. This is what is called the exchange of pins, which takes place every hundred meters. The chief of party takes note each time so as not to forget the number of hundreds.

572. To Measure by Horizontal Steps.—If the ground slopes down the head chainman takes a loaded pin in his right hand, raises the handle to get the chain horizontal and pulling on it hard, lets the pin drop. He replaces it afterwards by an ordinary pin.

573. Laying Out a Curve.—The tangents *CA* and *DB*, figure 5, plate 462, are given and they are to be joined by a curve the length of whose radius, *R*, is assumed, hence is known. If instruments are available, it is best, of course, to set a transit at *A* and having computed the subtended angle for a standard chain length, lay off from *A* successively the points on the curve to *B*. If a transit or compass is not available the curve may be staked approximately by the method of ordinates and abscissa as follows: For any abscissa

AP, which may be called *X*, the ordinate *PM* or *Y* is found approximately by the formula $Y = X/2R$. Thus, for example, if $R = 150$ meters, a table of ordinates and abscissa can be quickly computed.

X	Y
20m.	$20/300 = 1/15 = .66$ m.
40m.	$40/300 = 2/15 = 1.32$ m.
60m.	$60/300 = 3/15 = 1.98$ m.

The distances *X* are then measured from *A* along *AS* and the corresponding distance *Y* perpendicular to *AS*, thereby locating points on the curve. It will be best not to attempt to locate more than half the curve from *AS*. The same values may be used in locating the other half of the curve from *BS*.

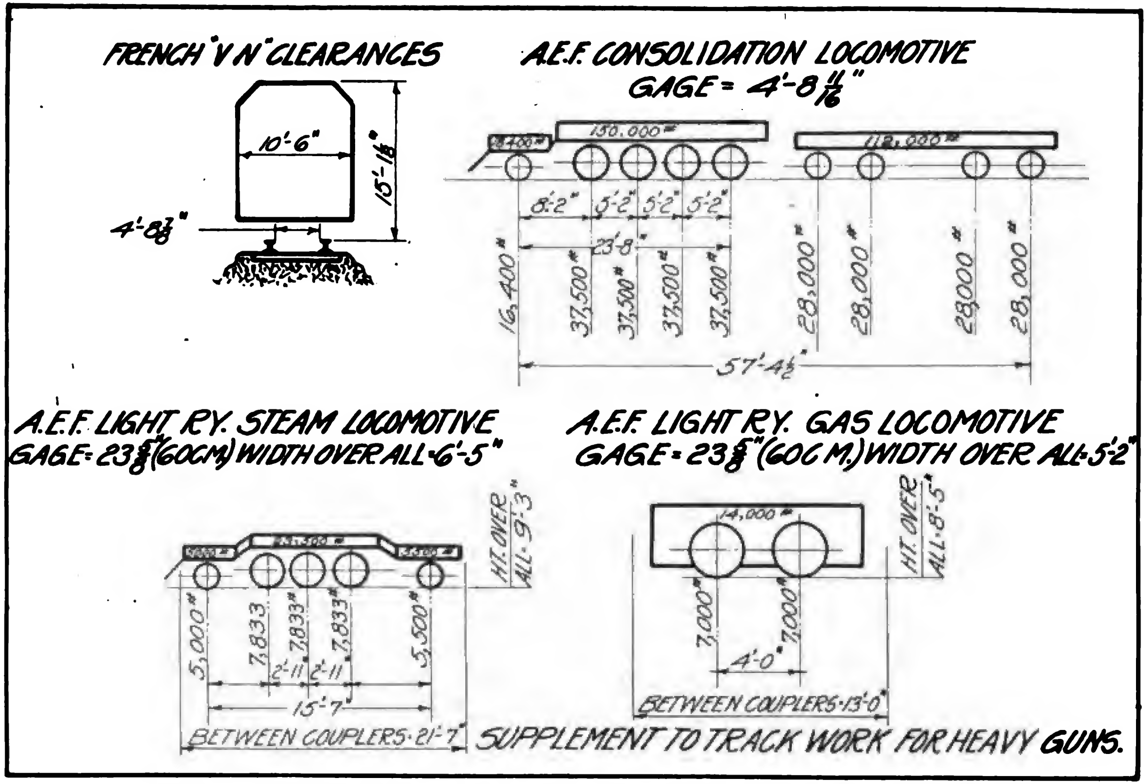
Table of coordinates on the tangent for laying off curves.

(Equal distances every 10 meters on the arc.)

Development of the arc from the point of tangency.	Radius of the curve (meters).											
	90		100		110		120		125		130	
	Abscissas on the tangent.	Ordinates.	Abscissas on the tangent.	Ordinates.	Abscissas on the tangent.	Ordinates.	Abscissas on the tangent.	Ordinates.	Abscissas on the tangent.	Ordinates.	Abscissas on the tangent.	Ordinates.
M.												
10	9.979	0.555	9.983	0.500	9.986	0.454	9.988	0.416	9.989	0.400	9.990	0.384
20	19.836	2.213	19.867	1.993	19.890	1.813	19.907	1.663	19.915	1.597	19.921	1.535
30	29.447	4.954	29.552	4.466	29.629	4.066	29.688	3.730	29.713	3.583	29.734	3.446
40	38.696	8.744	38.912	7.894	39.124	7.193	39.263	6.605	39.321	6.346	39.371	6.105
50	47.467	13.535	47.943	12.242	48.296	11.169	48.566	10.267	48.677	9.867	48.776	9.497
60	55.652	19.270	56.464	17.467	57.069	15.962	57.531	14.685	57.722	14.126	57.892	13.602
70	63.153	25.877	64.422	23.516	65.470	21.531	66.097	19.844	66.398	19.093	66.668	18.397
80	69.873	33.275	71.736	30.329	73.132	27.831	74.204	25.693	74.650	24.738	75.045	23.848
90	75.732	41.373	78.333	37.839	80.289	34.810	81.797	32.197	82.423	31.024	82.981	29.929
100	80.657	50.070	84.147	47.970	86.784	42.409	88.821	39.311	89.670	37.911	90.425	36.602

Development of the arc from the point of tangency.	Radius of the curve (meters).											
	140		150		160		175		190		200	
	Abscissas on the tangent.	Ordinates.	Abscissas on the tangent.	Ordinates.	Abscissas on the tangent.	Ordinates.	Abscissas on the tangent.	Ordinates.	Abscissas on the tangent.	Ordinates.	Abscissas on the tangent.	Ordinates.
M.												
10	9.991	0.357	9.993	0.333	9.993	0.312	9.994	0.285	9.995	0.263	9.996	0.250
20	19.932	1.426	19.941	1.331	19.948	1.248	19.956	1.142	19.963	1.052	19.967	0.999
30	29.770	3.202	29.801	2.990	29.825	2.804	29.853	2.565	29.902	2.364	29.888	2.246
40	39.457	5.674	39.528	5.302	39.585	4.974	39.653	4.552	39.705	4.195	39.734	3.887
50	48.943	8.834	49.079	8.257	49.190	7.749	49.322	7.094	49.424	6.541	49.482	6.218
60	58.180	12.661	58.413	11.841	58.604	11.119	58.831	10.185	59.007	9.395	59.104	8.933
70	67.118	17.138	67.487	16.039	67.788	15.070	68.148	13.814	68.427	12.749	68.579	12.126
80	75.716	22.241	76.261	20.833	76.868	19.587	77.242	17.969	77.656	16.594	77.884	15.788
90	83.927	27.945	84.696	26.200	85.328	24.652	86.085	22.637	86.671	20.920	86.993	19.911
100	91.710	34.221	92.756	32.117	94.616	30.246	94.644	27.801	95.446	25.713	95.885	24.484

PLATE 463



A. E. F. CONSOLIDATED, LIGHT RAILWAY STEAM, AND LIGHT RAILWAY GAS LOCOMOTIVES.

SECTION 6.

PREPARATION OF FIRING DATA AND SCHEME OF FIRE CONTROL FOR LAND WARFARE.

574. This discussion of the preparation of firing data and the scheme of fire control must necessarily be brief, and hence incomplete. No attempt will be made to give more than a general outline of the procedure. The theoretical points connected with the different methods of laying the piece will be considered first. Next the procedure in the case of a sliding mount firing from a curved epi will be described in detail, and, finally, a discussion will be given of the various corrections made to firing data and the methods of determining them.

575. Laying the Piece.—Laying the piece includes the operations of giving the gun the required elevation and direction. Laying in elevation is accomplished through the use of a vertical measuring instrument, such as the range quadrant, elevation quadrant, (pl. 464), or gunner's quadrant (pl. 465). Laying in direction is accomplished through the use of a goniometer (French) (pl. 466), or a panoramic sight (American) (pls. 467 and 468), in connection with an aiming or reference point.

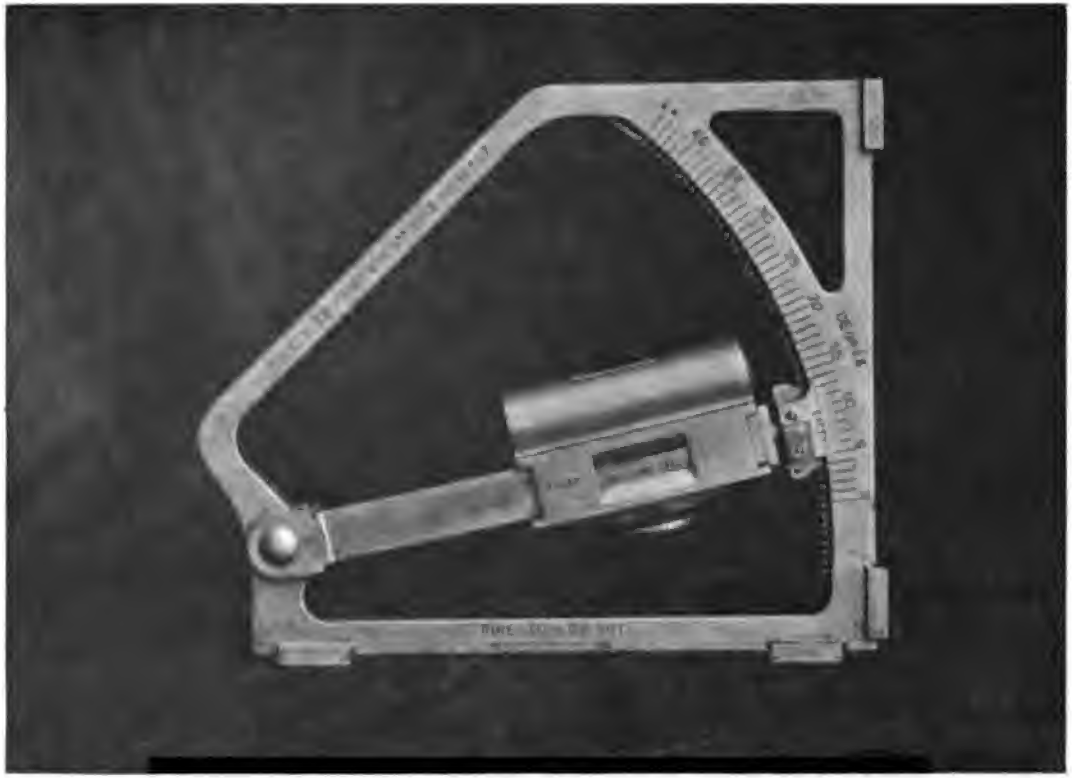
LAYING FOR DIRECTION.

576. Laying for direction is accomplished through the use of a few instruments of which there is a wide variety of designs, and on one of two principles differing radically in their basic conception. Under the one principle the laying diagram assumes the reference point at a finite distance from the sighting instrument, and under the other it is assumed at an infinite distance. In either case the sighting instrument is set at a calculated or measured angle (usually calculated), which is one of the two supplementary angles between two vertical planes, one of which passes through the axis of the gun and the other through the line from the gun to the reference point, and the gun is moved until the vertical cross line of the instrument is laid on the reference point. Obviously, then, when the sighting instrument is laid on the reference point the gun is pointing in the direction of the target. To determine the deflection angle, it is necessary to know the gisement of the line from the theoretical position of the gun to the finite or infinite reference point and to be able

PLATE 464

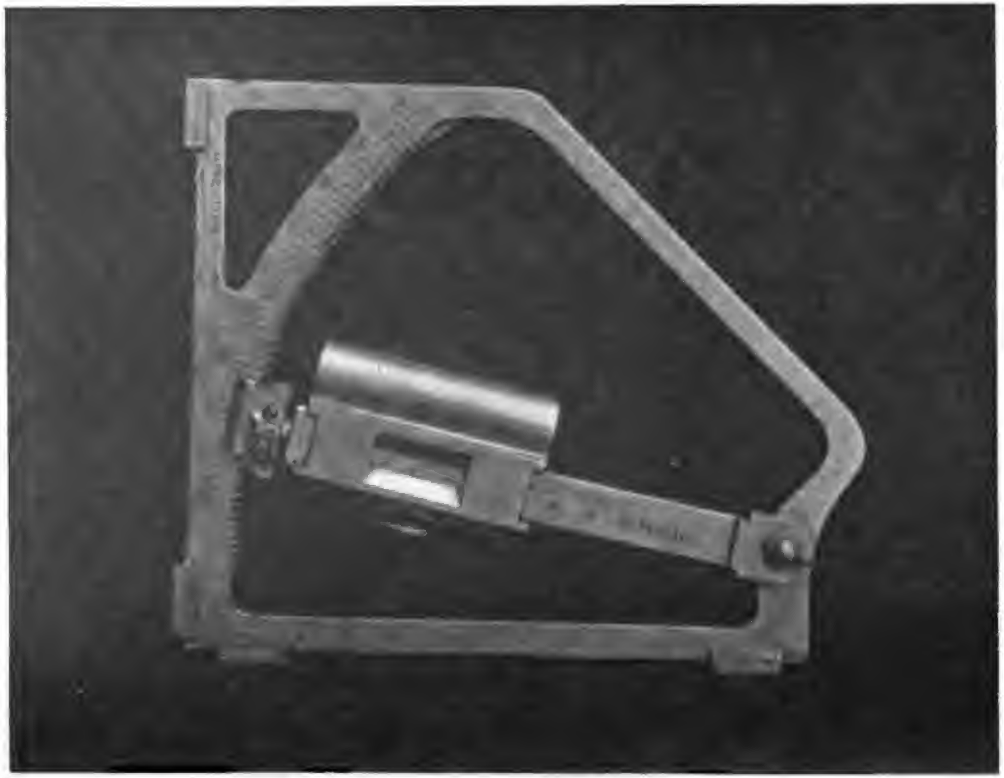
STANDARD ELEVATION QUADRANT USED WITH ALL RAILWAY MOUNTS.

PLATE 465



STANDARD GUNNER'S QUADRANT USED WITH MEDIUM AND HEAVY GUNS.

Plate 465A

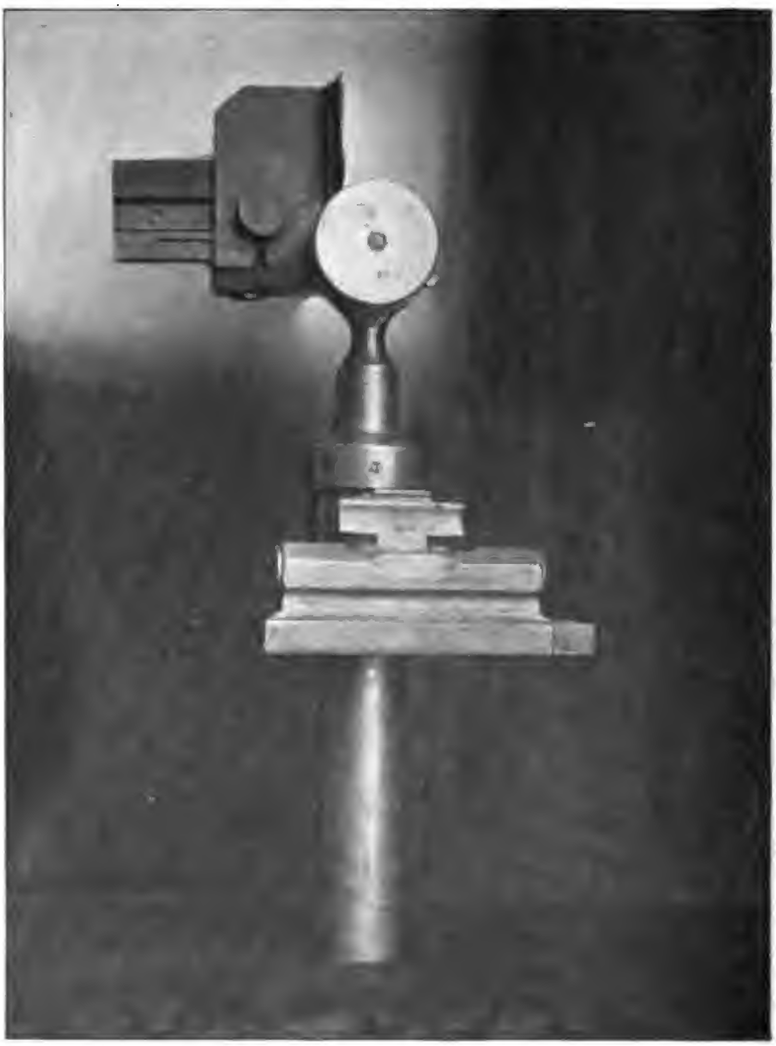


STANDARD GUNNER'S QUADRANT USED WITH MEDIUM AND HEAVY GUNS.

PLATE 466

GONIOMETER (FRENCH) FOR TRAINING GUNS IN AZIMUTH.

PLATE 466A



GONIOMETER (FRENCH) FOR TRAINING GUNS IN AZIMUTH.

PLATE 466B

GONIOMETER (FRENCH) FOR TRAINING GUNS IN AZIMUTH.

PLATE 467

STANDARD PANORAMIC SIGHT USED WITH ALL RAILWAY MOUNTS.

PLATE 468

PANORAMIC SIGHT MOUNTED ON AUTOMATIC SLOPE COMPENSATING MECHANISM.

to compute the gisement of the gun-target line. (The gisement of a line is its angular direction, measured clockwise, with reference to a north and south line through the zero point of the system of quadrillage. Azimuth is a somewhat analogous term, but is not exactly the same, since it is the angular direction of a line also measured clockwise, but with reference to a north and south line through the point at which the line is being considered. Since north and south lines are not parallel, obviously the azimuth of a line running, e. g., north 45° east, is not the same at points 5 miles or even 1 mile apart.)

577. Finite Aiming Point.—If the sighting apparatus is directed on a visible and fixed reference point, either improvised or natural, at a finite distance, this point is called a finite aiming point Under such circumstances the goniometer, or panoramic sight, is always attached to the gun and is set at the calculated angle. This scheme of laying is most generally applied to field mounts and to railway artillery having fixed emplacements.

578. Infinite Aiming Point.—If instead of a visible and fixed reference point an aiming rule is used, we have what is called an infinite aiming point. An aiming rule is a bar of iron L-shaped in cross section about a meter and a half in length, which is mounted on two heavy iron stakes set about a meter apart (pl. 469). Provision is made in the mechanism on the heads of the stakes for adjusting the bar both vertically and horizontally. In the outside of one leg of the bar there is a V groove in which two of the legs of the small iron tripod holding the goniometer, or panoramic sight, slide. When mounted on this rule a sight may be moved through a distance of nearly a meter and a half, all positions of the line of sight being parallel to each other. The use of an aiming rule, of course, always involves the use of either another sight or a mirror, adjustable for horizontal angles, mounted on the gun. The use of the aiming rule will be described in detail later.

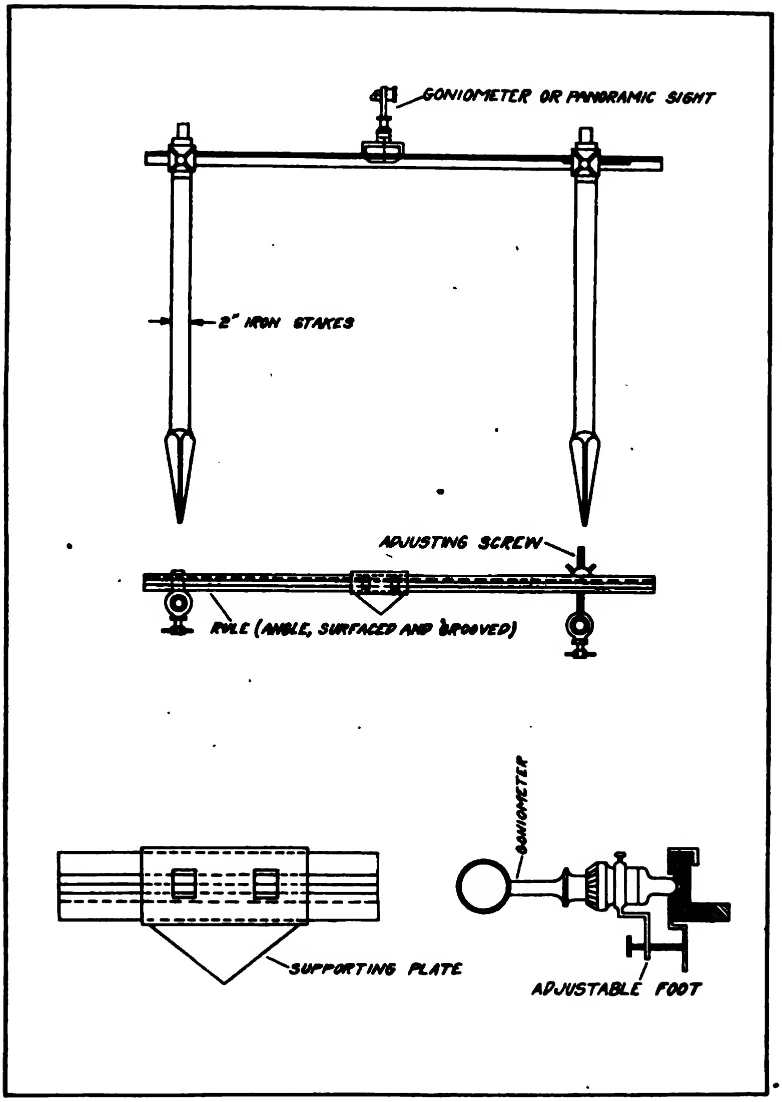
APPLICATION OF FINITE AND INFINITE AIMING-POINT METHODS TO RAILWAY ARTILLERY.

579. On the basis of methods of traversing and schemes of fire control railway artillery may be divided into three classes:

- Class 1: Guns provided with traverse and firing from fixed or semifixed emplacements on a straight track.
- Class 2: Guns provided with limited traverse and firing from a curved track.
- Class 3: Guns having no traverse and firing from a curved track.

580. Operation of Class 1—The emplacements of such mounts are so designed as to have satisfactory stability throughout the range of traverse provided. It is obvious that nothing can be secured in

PLATE 469



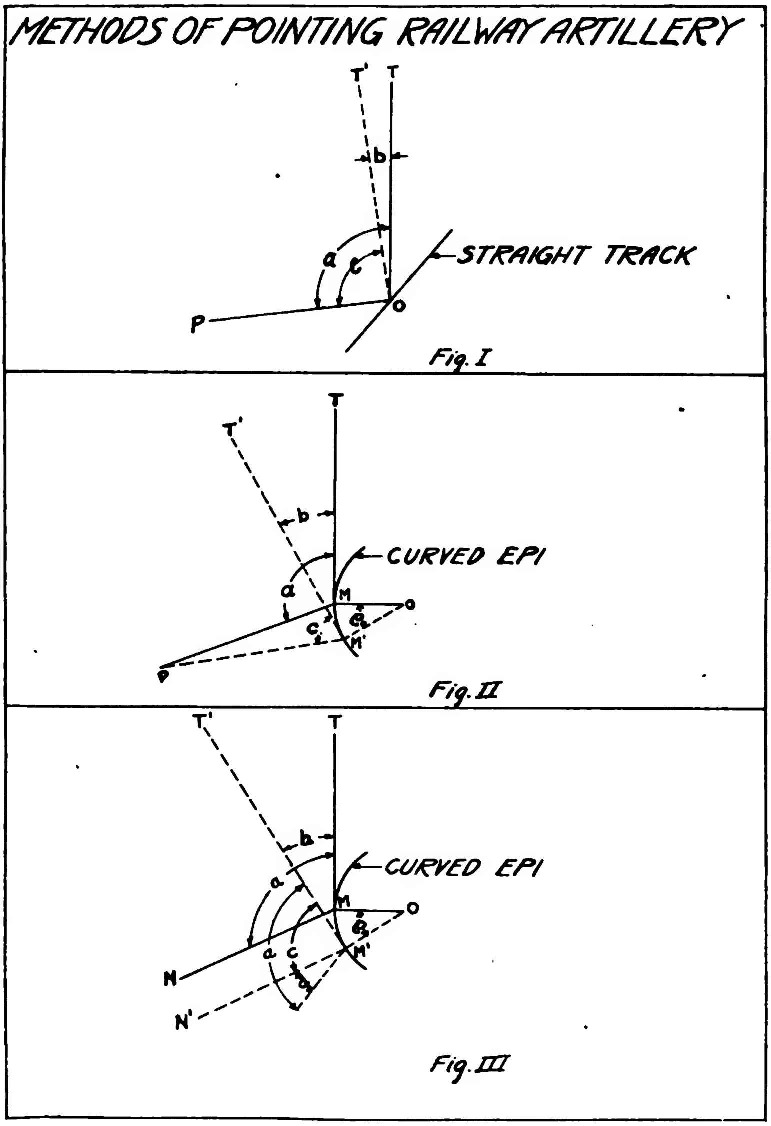
AIMING RULE FOR USE WITH RAILWAY ARTILLERY.

the way of traverse by moving the mount along a straight track. Since the emplacement is assumed to have satisfactory stability, there is no objection to the use of a finite aiming point. If *OT*, figure 1, plate 470, is the plane of fire, and the aiming point is *P*, and the deflection angle *a* is known, either from calculation or measurement, the gun is laid in direction by setting off on the sight an angle equal to *a* and traversing the gun until the vertical cross line of the sight is on *P*. If it is desired to change the direction of the plane of fire to *OT'*, it is only necessary to set the sight at a new angle equal to *a* minus *b* and to bring the sight again on the aiming point *P*. The method of infinite aiming point is likewise applicable to this class of artillery, and the writer recommends its use if time permits. When the guns are operating at extreme ranges, and it is not possible to observe the fire for accuracy, even slight displacements of the emplacement may throw the plane of fire off the target. Displacement of the emplacement does not have this effect when an infinite aiming point is used.

581. Operation of Classes 2 and 3.—Guns which are provided with car traverse usually have so little traverse that it is necessary to operate them on curved tracks to cover a large target or to enable them to operate on several targets. Guns which have no traverse must of course always operate on curved tracks. Any mount which must be operated on a curved track can not be operated with entire satisfaction through the use of a finite aiming point. First, it is inevitable that the track will be displaced from firing, and, second, it is quite probable that it will be necessary to operate on more than one target from the same track. When a finite aiming point is used, a displacement of the track involves a correction in the deflection angle, and the calculation of this correction is laborious. Further, a change of target with a finite aiming point, figure 2, plate 470, involves a calculation in the determination of the new deflection angle far more laborious than is required when an infinite aiming point is used, figure 3, plate 470. Although angle *e* equals angle *b*, figure 2, there is no simple relation between angles *a*, *b*, and *c*, and the computation of angle *c* becomes an entirely new trigonometric problem. In figure 3 it will be seen that the determination of the new deflection angle *c* involves only the determination of the angle *e*. For, angle *e* equals angle *b*; assuming *M'N'* parallel to *MN*, angle *e* then equals angle *d*, since angles *b* and *d* are equal. (*b* plus *c*—*a*—*c* plus *d*.) The new deflection angle *c* therefore equals the old deflection angle *a* minus the angle *e*.

582. Procedure in Detail for Sliding Mount on Curved Epi.—Under the head of "Procedure in preparing for action," section 5, it was mentioned that in the instructions received by the commander of heavy artillery to operate on a certain group of targets,

PLATE 470


METHODS OF POINTING RAILWAY ARTILLERY
T'
T
b
a
c
STRAIGHT TRACK
P
O
Fig. I
T
T'
b
CURVED EPI
a
M
O
c
e
M'
P
Fig. II
T'
T
b
CURVED EPI
a
M
O
e
a
c
M'
N
d
N'
Fig. III

the coordinates of these targets were given. From these coordinates the target may be located on a military map. On plate 471, T is one of the targets that has been so located. The artillery officer in charge of that sector decides that a position in the vicinity of G is to be the firing position and the orienteur officer, having the location of T and the approximate position of G, proceeds with the preparation of the data required for the construction of the epi curve as follows:

583. In general, one can see from any spot in France several prominent objects, church spires, monuments, etc., the exact locations of which are given in coordinates on the military maps; M, plate 471, is one of the points which the orienteur finds within view of G. Assuming that the artillery to be used is of the sliding type, class 3, the center and radius of the desired curve, the firing positions on the curve for the various targets and the extent of the curve must be determined.

584. From the approximate position of G, the center C is located, the radius being given, and if possible a stake is placed at C. The exact position of C is then determined from M and possibly other known points in sight by triangulation. The position of C is located in terms of the same system of coordinates as M and T. When the position of C is known, the gisement of the line $C\ T$ is determined either from the map or by computation. With the length and gisement of the line $C\ T$ determined, the epi is constructed and the various positions of C at which the gun will be placed for operation on the various targets are located, and the gisement of the various gun target lines $G\ T$ determined.

585. After G is located (on the outer rail), two other points 31 meters in front and 4 to the rear are located. Through these two points a line is run which is extended to the rear a distance of 80 meters. At the end of this line the aiming rule is placed on two iron stakes A and R. This rule is about a meter and a half long and is normal to the $G\ O$ line. Provision is made on the two iron stakes for any necessary adjustments of the rule. The next step is to determine the gisement of the normal to the aiming rule by means of a goniometer mounted on the rule. After the gisement of this normal is determined the value of the deflection angle $O\ G\ T$ can be computed. It is possible to compute this deflection angle in another way, as follows: Knowing the gisement of the line $C\ T$ and $G\ O$ and the value of the parallax angle $C\ T G$, it is possible to compute the deflection angle, corrected for wind and drift, by the use of Wilson's correction board.

586. With the sliding type mounts it is not possible to operate with satisfaction, using a panoramic sight and a distant aiming point.

PLATE 471

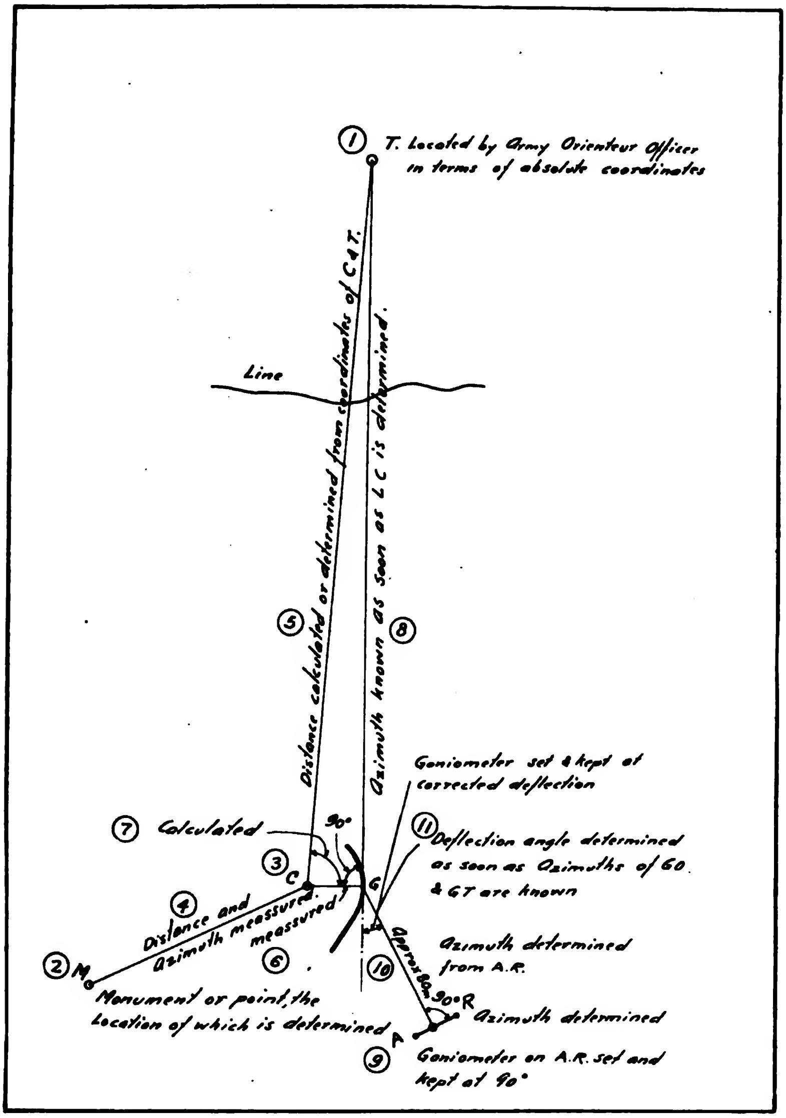


DIAGRAM OF FIRE CONTROL OF SLIDING TYPE OF RAILWAY MOUNTS.

In the event of lateral displacement of the track, which is inevitable, the continued use of the same deflection angle and finite aiming point does not by any means place the gun on the target. When the aiming rule is used, the only effect produced by lateral displacement of the track is the movement of the line of departure of the projectile to a new path, parallel to the former path and a distance from it equal to the extent of displacement, which may be only a few inches.

587. In action, the goniometer on the aiming rule is set normal to the rule. A mirror may be substituted for this goniometer. The goniometer on the mount is set at the corrected deflection angle. The mount is moved along the epi by means of the translating mechanism until the operators at the two goniometers G and O are each able to see the shank of the other goniometer at the same time. When this is possible, the gun is properly laid.

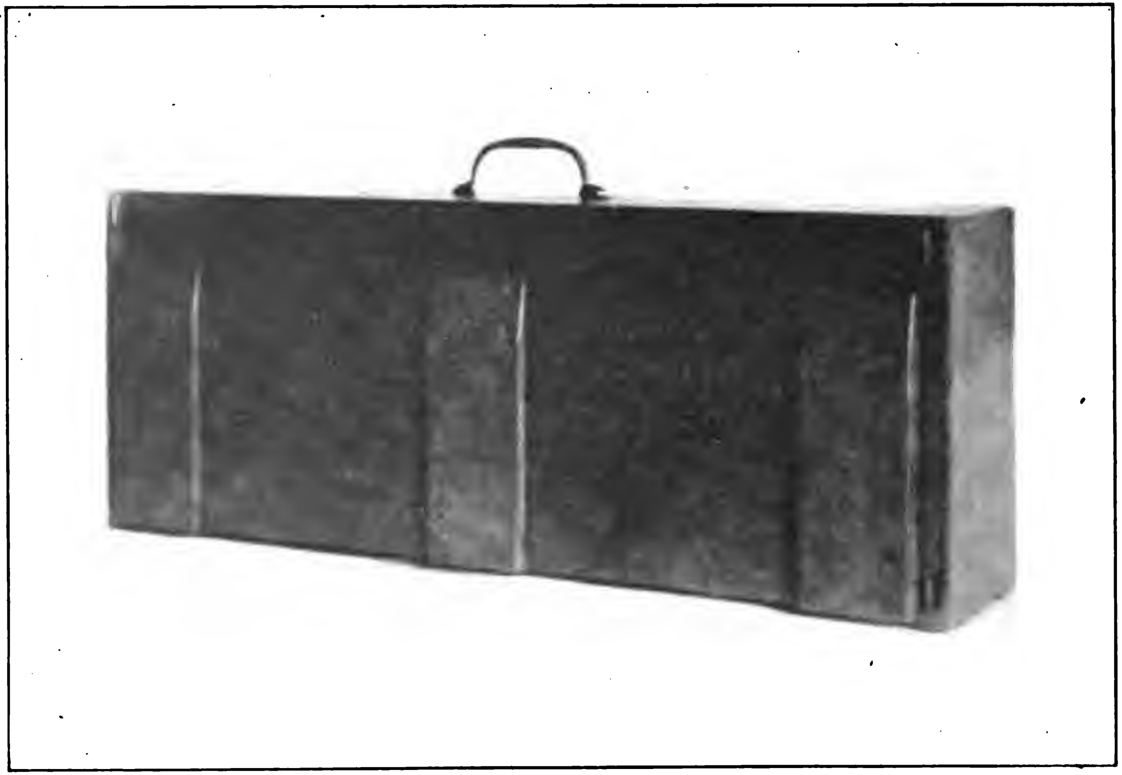
588. In the rapid determination of both the corrected deflection and range, Wilson's correction board, plates 472 to 475, is an invaluable instrument. By its use a computation that may require as much as an hour with possibility of error may be made with little mental effort and little chance of error in less than five minutes. This instrument determines the deflection, corrected for wind, drift, and parallax. It likewise determines the range corrected for atmosphere, wind, powder velocity variation, variation in projectile weight, and height of site.

589. Comments concerning certain of the above factors entering into the correction of the range and deflection may be of interest. With reference to the atmosphere, a certain degree of saturation is assumed by the French as a standard. The thermometer and barometer readings then enable one to determine the density.

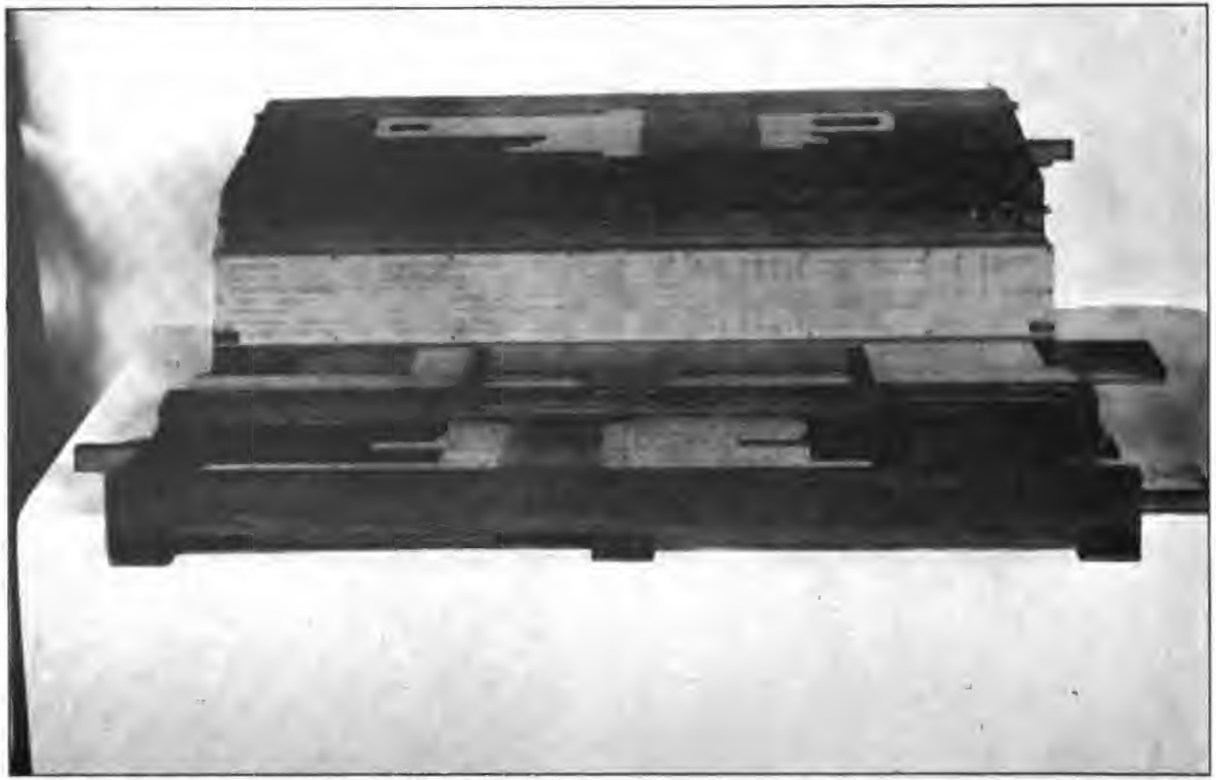
590. The air service of the Engineer Corps sends out every few hours, by wireless, data on the ballistic wind. Their method of determining the ballistic wind is as follows: Small balloons of a standard size, about a meter in diameter, are inflated with hydrogen until their lifting capacity is a certain amount. A balloon is released from a certain spot which becomes an origin for later computations and the position of the balloon is observed at regular intervals. From all of these observed readings mean directions and mean velocities are computed in terms of various elevations. The information that is sent out is then: Elevation, X; velocity, Y; direction, Z; Y being the mean direction of the wind for a maximum ordinate of X. This mean effective wind for elevation X is called the ballistic wind. This data is given for various elevations, so that the various battery commanders firing guns with trajectories of different maximum ordinates will all have the data they need.

591. The correction board already mentioned may also be used to analyze certain results in the field. For example, if the range is X,

PLATE 472

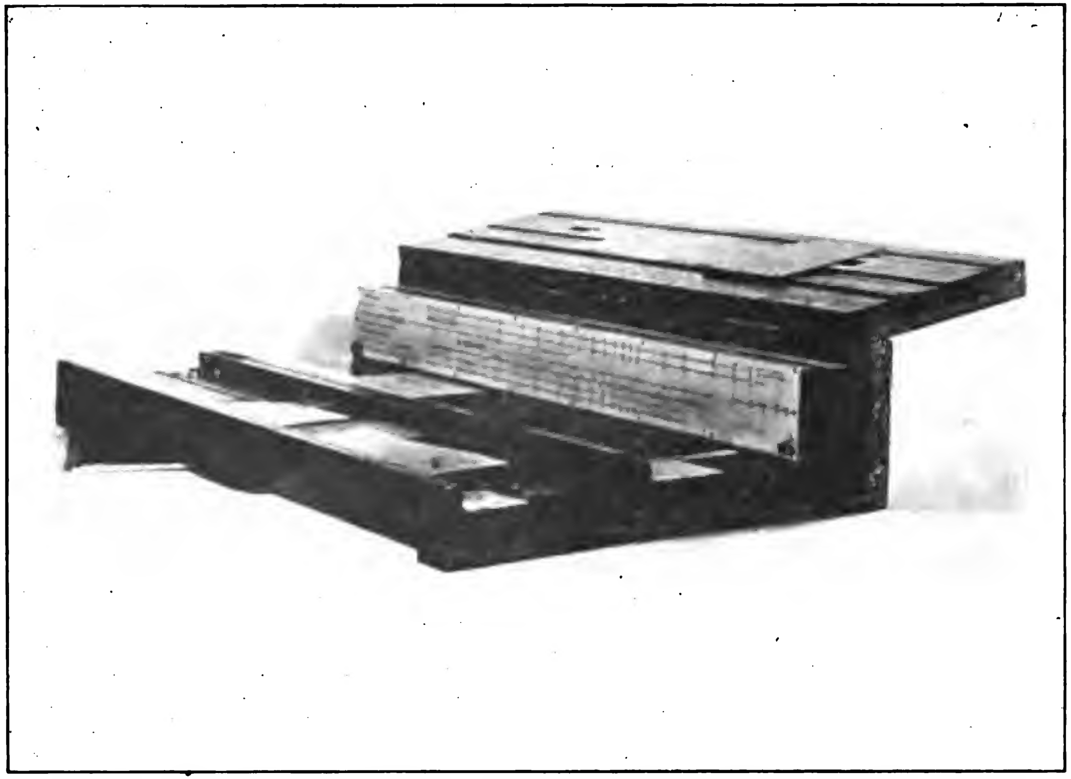


WILSON'S ELEVATION AND DEFLECTION CORRECTION BOARD (CASE CLOSED).



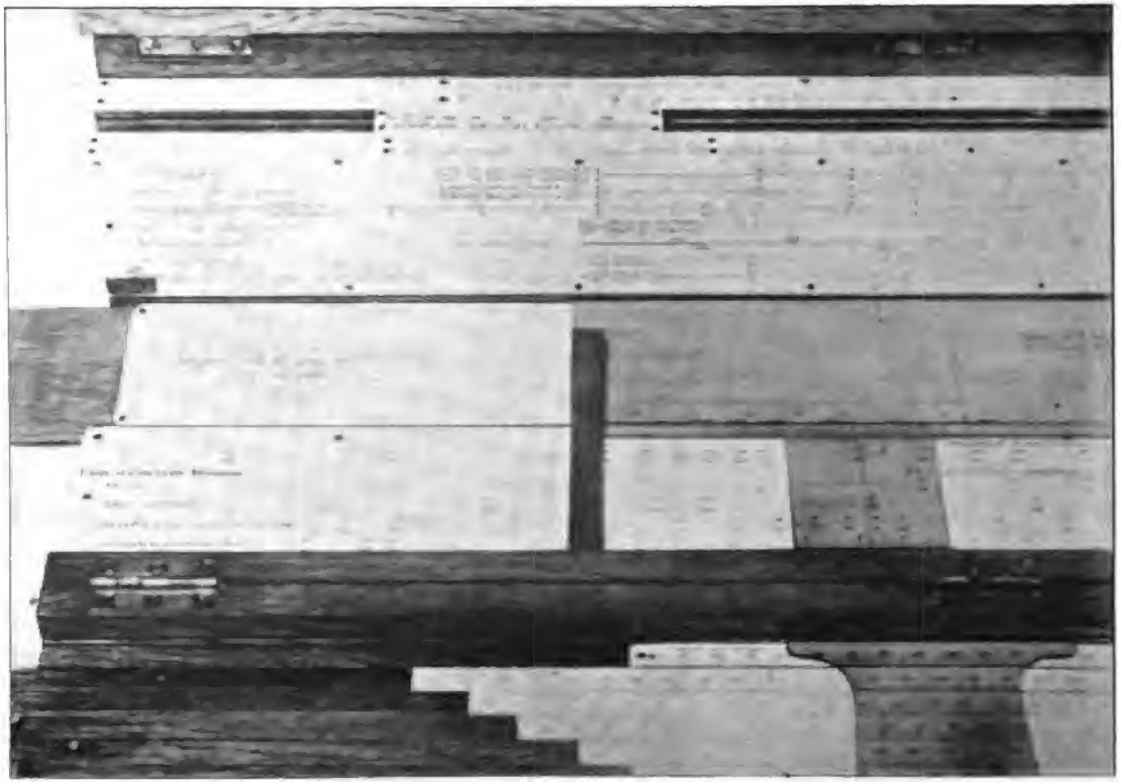
WILSON'S ELEVATION AND DEFLECTION CORRECTION BOARD (CASE OPEN FOR SERVICE).

PLATE 474



WILSON'S ELEVATION AND DEFLECTION CORRECTION BOARD (CLOSE VIEW SHOWING SCALES).

PLATE 475

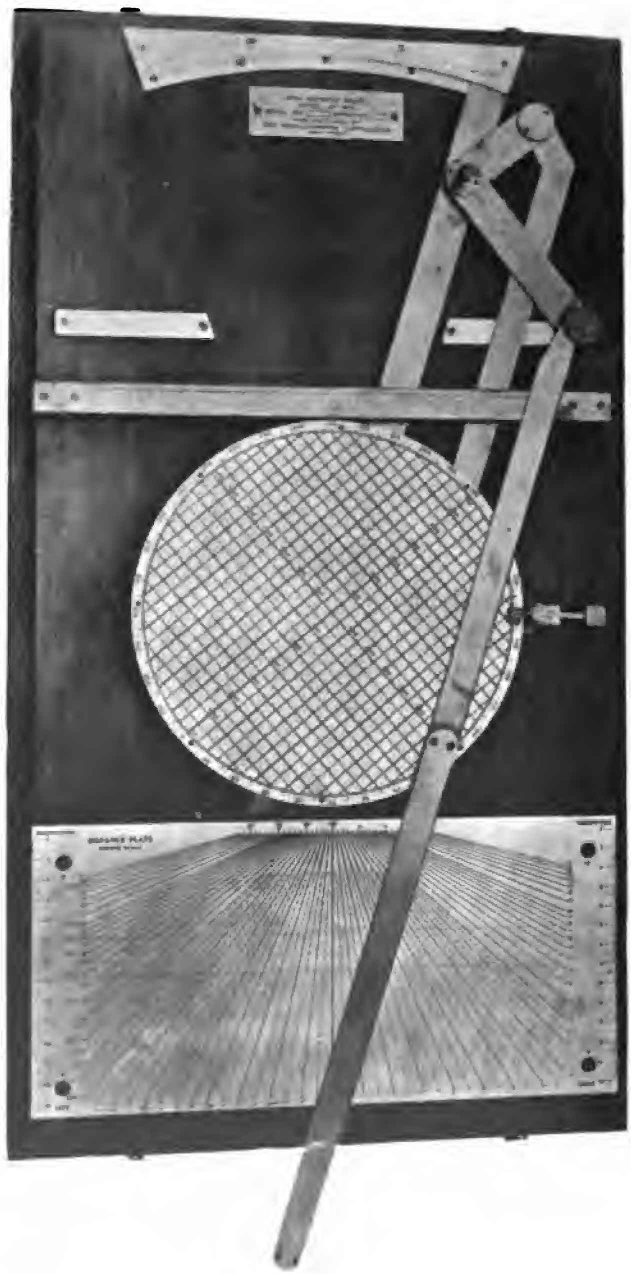


WILSON'S ELEVATION AND DEFLECTION CORRECTION BOARD (CLOSE VIEW SHOWING SCALES).

the corrected range Y, and the center of impact of the group of shots is at a point whose range is Z, assuming the wind, atmosphere, and projectile weight factors to be correct, one may work back to determine the actual powder velocity.

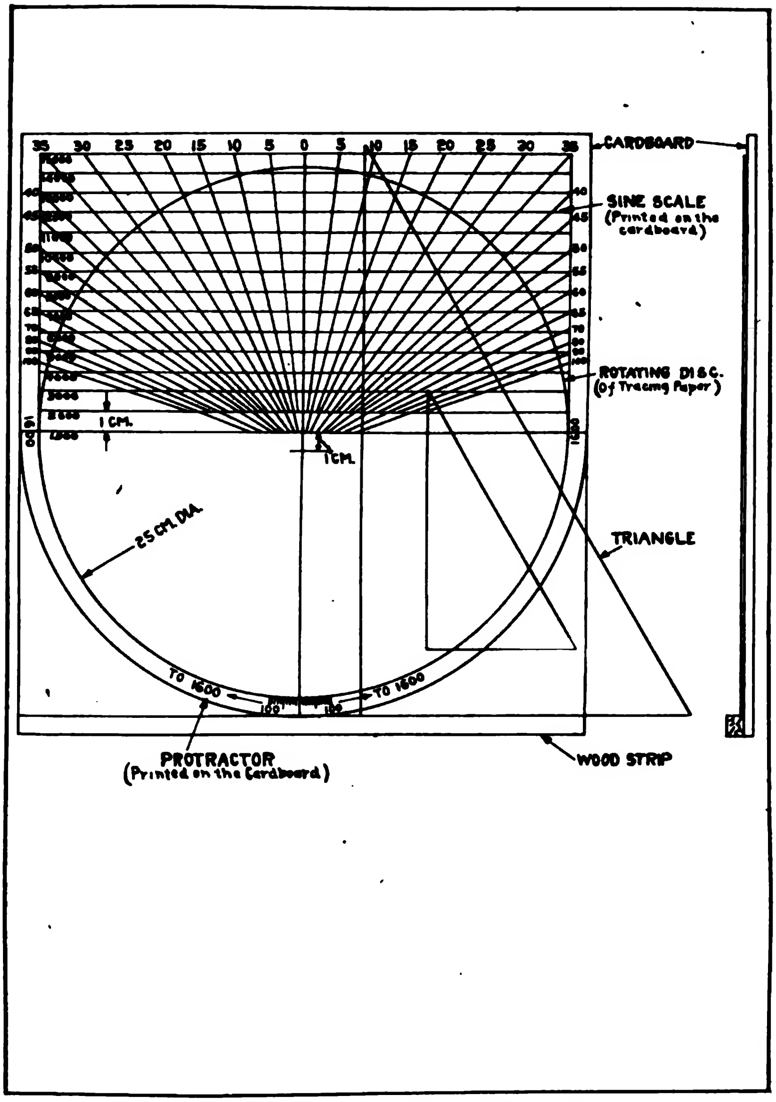
592. For the correlation of the observations of the terrestrial observers the deviation board, plate 476, is the best device. This board was devised by Col. Pirie in France and later modified and simplified to two sheets of paper and a triangle or T square, plate 477. The board is an adaptation of the French system, which is as follows: A sheet of paper is stretched over a plate of zinc and the point T, target, is located about in the center, figure 1, plate 478. The positions of the three observers, O_1, O_2, and O_3, are then located accurately, either on or off the board, usually off. With these points as centers, two arcs are drawn for each. A line through O_1 and T locates zero for that observer; the arcs are graduated on each side of zero; so also for O_2 and O_3. When the observers at these three points observe a burst it is plotted as shown; e. g., O_3 reports the burst 5 mils to the right; a line is drawn through the 5-mil points on the two arcs whose center is O_3. Similar lines are drawn for O_1 and O_2, according to their reports. The burst is supposed to be in the center of the resultant triangle.

593. In the French Army the aerial observer uses a photograph of the region on which the target is located; this photograph is carefully ruled in checker-board fashion. The observer locates the burst on his photograph and reports the distance to the right, left, over, or under. The battery commander plots these reports on a sheet ruled as in figure 2, plate 478. It will be noted that the up and down lines are convergent; they pass through the battery position. It will be noted also that these lines are labeled both in yards and in angular units for the quick translation of the observations. The horizontal lines are likewise labeled in terms of distances and angles. It may be well to mention here that one car of the standard A. E. F. design, plate 479, was fitted to serve as a fire-control car. Plans were made to supply these cars for service in France, but on advice from France that they were not desired the plan was abandoned.

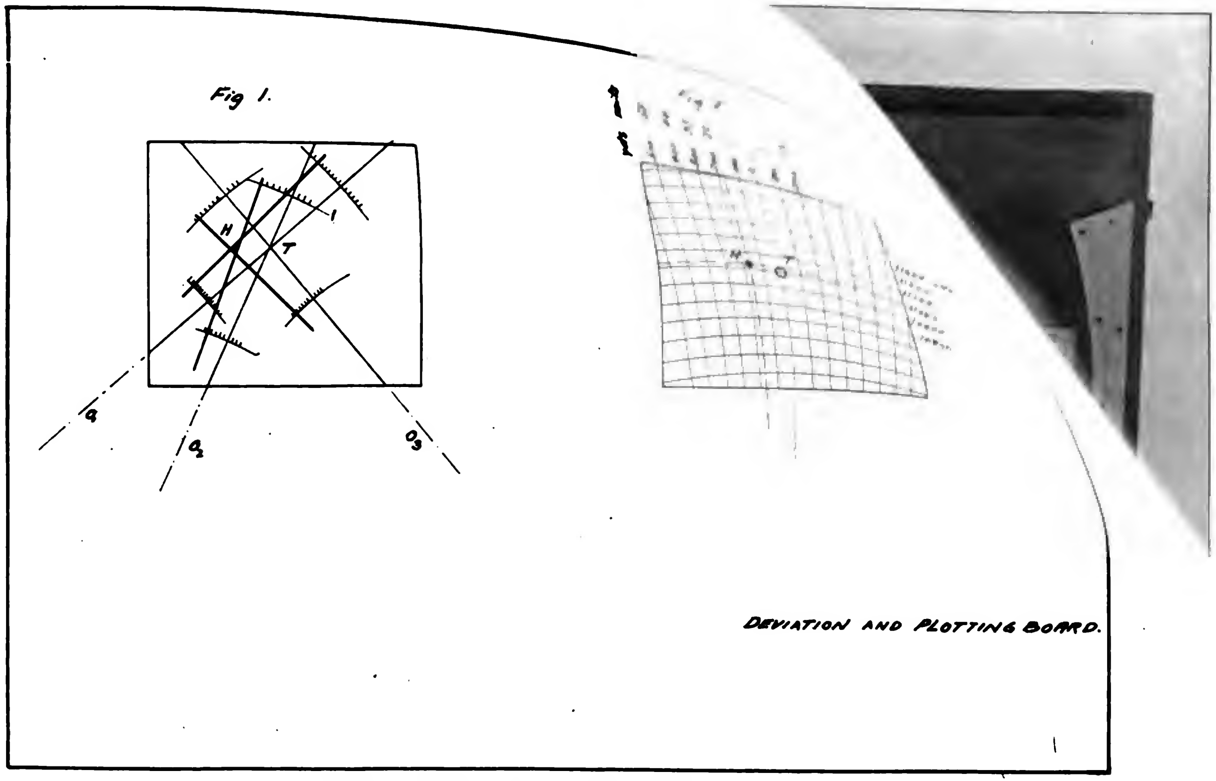


PIRIE DEVIATION BOARD.

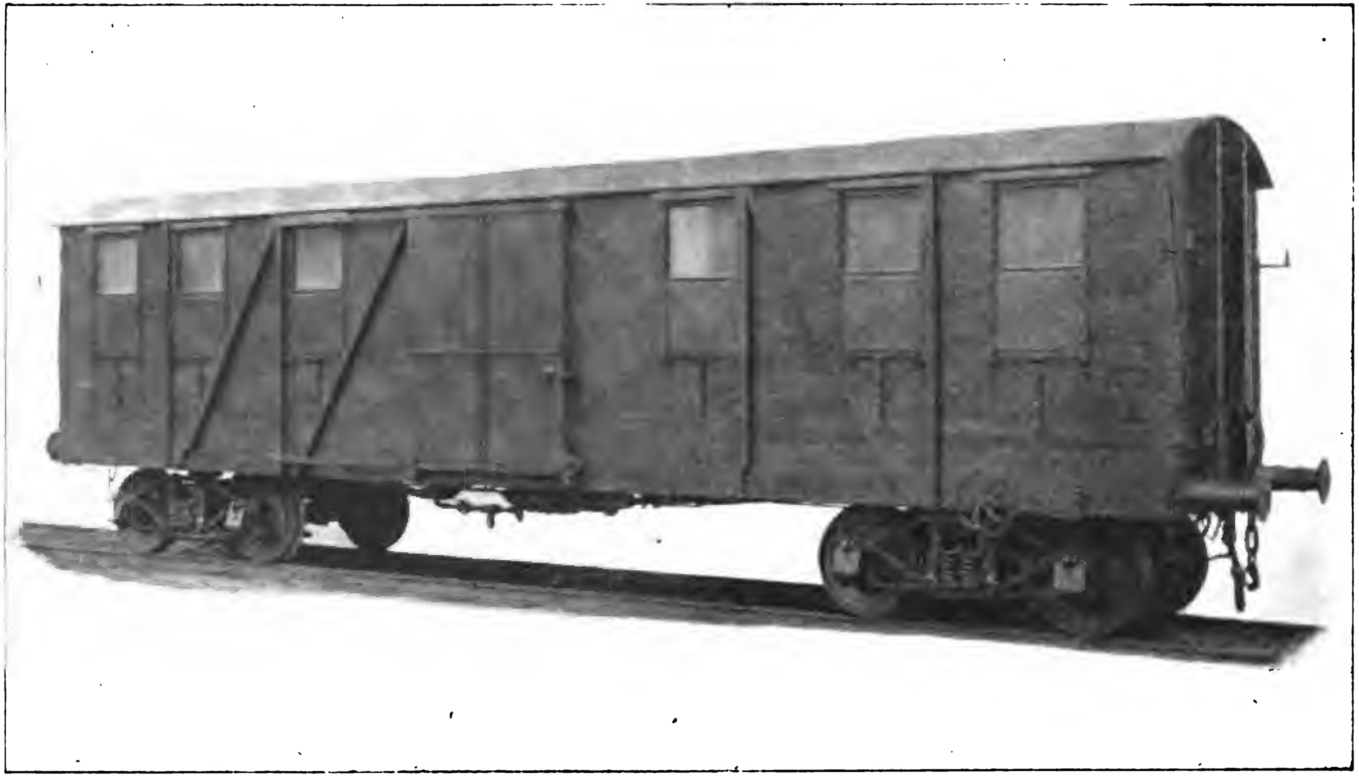
PLATE 477



UNKLE'S SIMPLIFIED DEVIATION BOARD.



SIMPLE DEVIATION AND PLOTTING BOARDS.



STANDARD A. E. F. BOX CAR FITTED TO SERVE AS RAILWAY ARTILLERY FIRE CONTROL CAR.

PLATE 478

Fig 1.

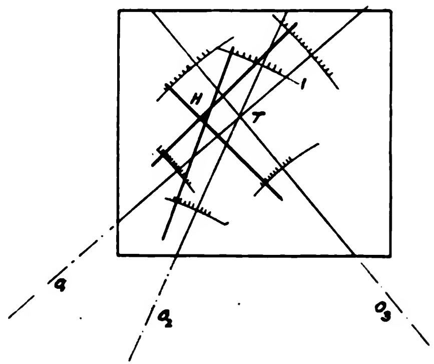
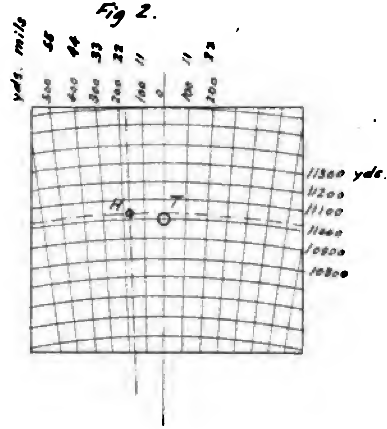


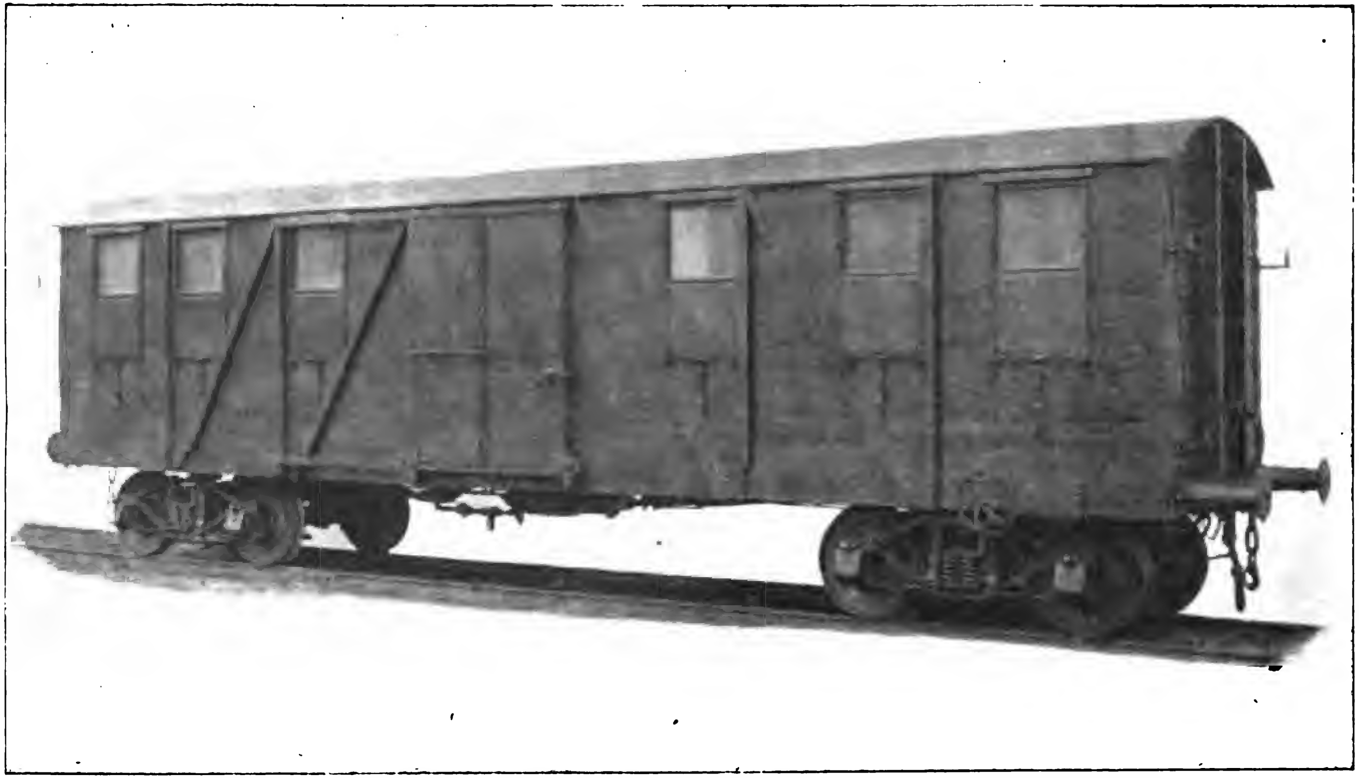
Fig 2.



DEVIATION AND PLOTTING BOARD.

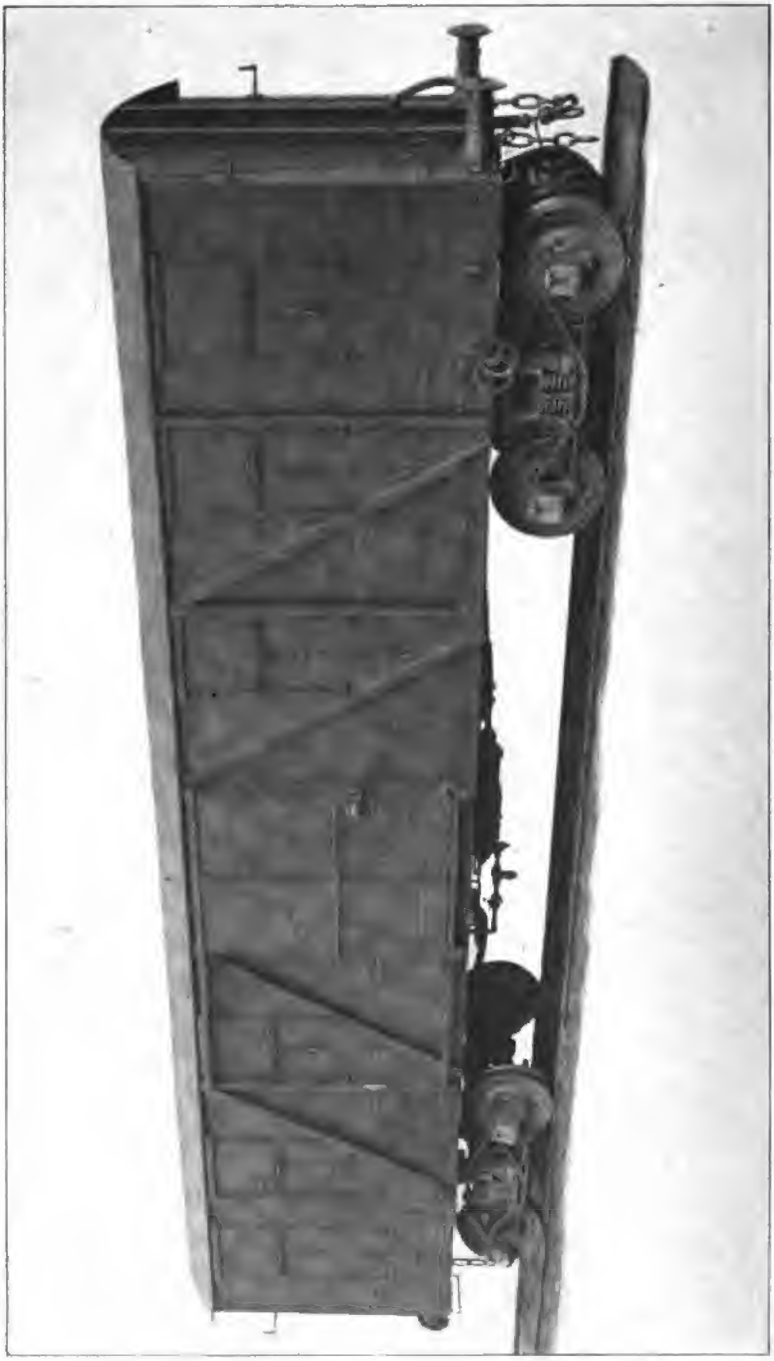
SIMPLE DEVIATION AND PLOTTING BOARDS.

PLATE 470



STANDARD A. E. F. BOX CAR FITTED TO SERVE AS RAILWAY ARTILLERY FIRE CONTROL CAR.

PLATE 480



RAILWAY ARTILLERY REPAIR CAR.

SECTION 7.

ASSEMBLY, DISPOSITION, AND MAINTENANCE OF RAILWAY ARTILLERY IN LAND WARFARE.

594. It is intended to treat here the general problems of the care of matériel that come up in connection with railway artillery. These will be treated under the headings of assembly, disposition, and maintenance.

595. ASSEMBLY.—Ordinarily, railway artillery is shipped on its own wheels, but in the case of the European war, all of that which came from England and America had to travel by water and was, of necessity, disassembled to a greater or less degree.

596. The experience of the English and of the American Navy indicates that such mounts should be disassembled as little as possible, and, in general, it was found possible to limit the subdivision to the following:

1 unit, gun and cradle.
1 unit, main girder and carriage.
1 unit, each span bolster.
1 unit, each truck.

On the very heavy mounts, it was necessary to make a separate load of the cradle. In all cases, also, the small and projecting parts were removed and packed separately.

597. The importance of providing heavy pieces such as the girders with proper lugs and rings for hoisting and handling, can not be too strongly emphasized. The designer often loses sight of this detail so valuable to the men who are charged with loading and unloading and assembling. As little work as possible should be left to be done at the assembly shop; in particular, drilling and riveting.

598. Particular care should be exercised in protecting bright exposed metal surfaces before shipping overseas. In many cases this was not done with guns and parts received in the present war, and considerable time was lost in cleaning.

599. A careful study was made of the erection of the American naval mounts and a summary of recommendations with reference to

equipment and personnel is given below. The equipment should include besides a full line of suitable hand tools:

(*a*) At least two, and better, three or four parallel and adjacent tracks at least 700 feet long for unloading and erection.
(*b*) Compressed-air plant and distribution system.
(*c*) A locomotive crane of suitable capacity.
(*d*) Overhead cranes of suitable capacity.
(*e*) Three tool houses.
(*f*) Field shop and office.
(*g*) Office for Superintendent of Construction.
(*h*) Barracks.

The personnel recommended for this work includes:

(*a*) Commanding officer—major.
(*b*) Construction officer—captain.
(*c*) Adjutant, camp administration—lieutenant.
(*d*) Accounting and purchasing officer—lieutenant.
(*e*) 150 men, subdivided as follows:
19 checkers.
10 laborers, yard and camp.
3 laborers, warehouse.
1 chauffeur.
3 office force.
26 guards.
2 tool keepers.
3 orderlies.
3 mess.
1 latrine man.
15 expert mechanics.
58 railroad men—car and locomotive builders, track men, etc.
3 extra men.

This arrangement was contemplated for the erection of a program of six months. With an actual organization about the same, a 14-inch mount was erected in 10 days.

600. Disposition.—In the British Army, the railway artillery is classed as corps artillery and distributed as such. The plan followed in the American and French armies is the one which would be inferred from section 2, "The Scope of Utility of Railway Artillery," and section 5, "Procedure in Preparing for Action." This artillery is too valuable, too expensive, and too slow in building to be used except as necessity requires. It is felt that there is no merit in keeping the pieces located in various positions along the front on the theory that they would probably be needed in those localities.

Railway companies do not purchase a number of locomotive cranes and place them at short intervals along the line for chance emergencies. The cranes, as well as the railway artillery, are so mobile that they can be quickly transferred wherever needed, and, when not needed, are kept where they are both out of the way, well protected, and easily maintained. The British scheme of corps railway artillery is felt to have resulted in very poor economy in the utilization of this matériel.

601. In the case of the French and American Armies, a certain camp, about 30 miles behind the lines, was established for both the matériel and personnel of the railway artillery. In the yards of this camp were found the mounts and all rolling-stock equipment. At this distance behind the lines it is comparatively easy to maintain the personnel of the groups and not in any way to draw upon the facilities required to maintain the personnel at the immediate front. This camp was likewise on a well-established railway line and all supplies could easily be secured. This plan worked out well in both Armies.

602. Inspection.—Inspection of railway artillery is carried out in different ways by the different armies. In the French Army the inspection service is under the Commission A. L. V. F. (heavy railway artillery). Regular inspections are made at considerable intervals and routine notes are taken on condition of matériel. Upon the occurrence of any accident a member of the inspection service is at once sent for to render an opinion as to what should be done. Such records as were seen of the French guns were quite general in character.

603. In the British Army the inspection service is under the Ordnance Corps. It makes regular and special inspections, in the same manner as the French, but more frequently and in greater detail.

604. In the American Army the inspector was detailed from the Ordnance Department, but his line of authority was not clearly defined, and efforts were made to bring him under the authority, respectively, of the Railway Artillery Reserve (the operating branch), the Ordnance Repair Shop (the maintenance branch) and the Engineering Division of the Ordnance Department (the technical and designing branch). A final arrangement was never worked out.

605. As a result of observation and experience, however, it is felt that the inspector should, of necessity, be free from the authority of the artillery commander, whose use of the guns the inspector's work is expected to keep within proper bounds, and likewise free from that of the officer in charge of maintenance, whose work the inspections should constitute a check on.

606. It is felt that the arrangement employed in the French and British Armies, where the inspector is responsible solely to the Technical and Design Service, is the proper one. Inspections should be frequent and thorough and adequate records of each piece of matériel should be kept. As an illustration of what it is felt is required in this connection, an abbreviated copy of the Railway Mount Service Book, as made up for the use of the American Army, is given on the following pages.

607. Text and Outline of Railway Gun and Mount Service Record.

[Cover.]

RAILWAY GUN MOUNT SERVICE RECORD.

MOUNT.

Model..

Number..

Mark..

PREFACE.

Railway artillery is comparatively new to all armies, and especially so to the Army of the United States. In consequence, many difficulties have been experienced in the manufacture of railway artillery matériel, and considerable delay has been entailed by the necessary study of many unfamiliar details.

Similar difficulties and delays in the future can be minimized by studies based upon current experience. To make this study complete, it is necessary to check the theoretical knowledge of the designer by the practical experience of field personnel; to know whether the various parts function properly; and if not, why not.

While the records desired are more elaborate than those heretofore requested of battery commanders, the arrangement of the book is such as to make it a convenient means of recording the desired information. Ample spaces, under descriptive headings, are provided for information concerning practically every principal part of the carriage; difficulties experienced, observations, recommendations, and explanatory sketches.

Only the conscientious cooperation of the battery commander in furnishing complete data will enable the designers to produce the nearly perfect machine that the field personnel would like to have.

TABLE OF CONTENTS.

INSTRUCTIONS.

This book is always to remain with the mount, and is never to be removed except for the purpose of making entries, after which it is immediately to be returned to its proper place on the mount.

Entries.—The entries are to be made at least once every 24 hours, when the mount is in service, by the gun commander, under the supervision of the battery commander.

Record of assignment of mount.—The entries indicated on this page will be made immediately upon receipt of the mount.

Daily gun record.—In this section of the book, under the respective headings, there will be entered the number of shots fired, proportional weight of powder charges, type of shell, type of fuse, range, and elevation. In the column headed "Remarks," there will be entered short notes, such as a note of an inspector's visit, damage to gun or mount, nature of work the gun is used for (i. e., counterbattery, interdiction, or destruction), date sent to or received from the repair shop, date of transfer to another battery, and other short items with reference to any detailed entries on other pages.

Information in detail.—The table under this head indicates the desired information concerning each principal part or group of parts, but is not intended to limit the information furnished. This should be entered on the blank pages following the table and should include all available data as to poor functioning, weaknesses developed, wear noted, changes suggested, etc. Make these entries as soon as difficulties are experienced or defects noted. Sketches are of great value and should be a feature of such entries. Before an entry in this section the number of the page on which it is to appear should be entered in the index pertaining to the part or group concerned.

Reports of prematures.—These are to be made on the blank forms bound into the back of the book. They are to be rendered in accordance with the instructions printed thereon.

Record of Assignment of Mount.

MOUNT.

Model..

Number..

Mark..

Date.	Gun caliber.	Model.	Modification.	Number.	Battery.	Regiment.	Battery commander.

Daily Gun Record.

Gun:
- Caliber............................
- Model............................
- Modification........................
- Number............................

Mount:
- Model.................................
- Number.................................
- Mark.................................

Date.	Number of shots.		Size of powder charge.	Type of shell.	Type of fuse.	Range.	Elevation.	Remarks.
	Full charge.	Reduced charge.						

[47 pages of this form to be inserted.]

INFORMATION IN DETAIL.

On the pages following this table there will be entered full data concerning faulty functioning, weaknesses developed, undue wear, etc., with recommendations and explanatory sketches. The table indicates the nature of the desired information concerning the principal parts of groups, and will serve as an index to the entries. Make entries as soon as a fault becomes apparent, and index them in the designated spaces below.

Part or group.	Information concerning—	Index.			
		Page.	Page.	Page.	Page.
Gun	Wear of bore, shifting of hoops, and all other information concerning tube, hoops, or jacket. Give model, modification and number of gun, and date of entry.				
Breech mechanism	Condition of obturator, replacement of parts, wear action, etc. Give model, modification and number of the gun, and date of entry.				
Firing mechanism	Difficulties experienced, observations and suggestions. Give model, modification and number of gun, and date of entry.				
Cradle	Condition and operation of all parts of cradle. Give date of entry.				
Elevating mechanism	Difficulties, slowness, jamming, etc. Give date of entry.				
Traversing mechanism	Details of any difficulties, notes as to keeping on targets, etc. Give date of entry.				
Recoil	In the case of spring recoil, renewal of springs, of oil, etc.; case of sliding mounts, action of recoil, troubles, suggestions, etc. Give date of entry.				
Recuperators	Operation, leakage, renewal of oil and air, troubles, etc. Give date of entry.				
Carriage	Traversing rollers, trunnions, bearings, antifriction device, etc. Give date of entry.				
Sights	Adjustments, troubles, causes, suggestions. Give date of entry.				
Main girders and transoms	All details of interest. Give date of entry.				
Truck and frames	All details of interest. Give date of entry.				
Translating mechanism	Action and condition. Give date of entry.				
Jacks	Action, rapidity, troubles, etc. Give date of entry.				
Bolsters	All details of interest. Give date of entry.				
Brakes	Action, wear, and general condition. Give date of entry.				
Outrigger	Rigidity of mount, rapidity of mount, rapidity of setting, bending, etc. Give date of entry.				
Firing beams	Details as to wear, etc. Give date of entry.				
Loading mechanism	Rapidity, ease of handling, and suggested improvements. Give date of entry.				
Power unit	Reliability, power, and other points of note. Give date of entry.				
Epis	All details of interest. Give date of entry.				
Transbordeur	Points pertaining to operation. Give date of entry.				
Ammunition car	Condition of contents, ease of handling, etc. Give date of entry.				
Ground platform car	Details as to ease of handling contents, etc. Give date of entry.				
Ground platforms	Rigidity, time to set, wear, suggested improvements, etc. Give date of entry.				
Narrow-gauge equipment	All details of interest. Give date of entry.				
Other cars	All details of interest. Give date of entry.				
Other equipment	All details of interest. Give date of entry.				

[Faint ruled, both sides, with horozontal and vertical lines 5 millimeters apart, for entry of information in detail, 81 pages.]

BATTERY COMMANDER'S REPORT OF PREMATURES WITH GUNS, HOWITZERS, AND MORTARS, 37-MM. CALIBER AND ABOVE.

Organization.......................... Date of report........................19..

Gun, howitzer, or mortar.................. Caliber........... Model.............

Date of premature................19.. Rounds fired to date............ Rate of fire........... Rounds per min. for.........mins. before accident. Did projectile burst inside or outside the bore?.............. Distance from muzzle...........

Color of smoke observed: Black........... Gray............. White.............

TYPES AND MARKINGS OF AMMUNITION.

Taken from round fired, or next of same lot?......................................

Fuse: Type............... Model............... Shape head....................

Color head........... Color body........... Lot No...........

Projectile: Type........... Model–.................... Color ogive....... Color body............. Stamped markings.......... Lot No...........

Cartridge case: Stamped markings......................... Lot No...............

Propellant: Type..

Weight...

Normal...

Reduced.......... Zone No...........

Bag markings...

EXAMINATION OF FRAGMENTS OF PROJECTILE AND FUSE.

Did explosive adhere to fragments?................ How?......................

Edges: Sharp, square, or melted?........ Smoke blackened or heat blued?........

Fragments: Large or small?...................... Where found?..................

Remarks:...

[Pages 137 to 144 will be duplicates of this copy, but will not bear folio No.; they will be perforated ½ inch from the hinge.]

INSTRUCTIONS.

Original and two carbon copies of this report will be made by the battery commander as soon as practicable after the premature occurs, and will be sent direct to the Chief Ordnance Officer of the Army. Details concerning abnormal or short rounds should be noted under "Remarks".

(Signed).......................................

Battery Commander.

608. MAINTENANCE.—The discussion of railway artillery must, of necessity, be very incomplete, but an effort will be made to enumerate the chief matters which have come to the writer's attention in connection with it. First, cannon and then mounts will be considered and the types of wear and breakage and the methods of repair will be

discussed. Then shop equipment and organization for taking care of maintenance will be set forth.

609. CANNON.—The chief difficulties requiring maintenance in connection with cannon are derangement of breech and firing mechanisms, coppering of bore, bursting and swelling of tubes, and wear. The derangements of breech and firing mechanisms are merely small mechanical difficulties, the caring for which requires only a supply of spare parts and small size machine-tool equipment.

610. Coppering of the bore from rotating bands is a very serious difficulty. On the 14-inch Navy guns, after about 200 shots, this deposit of copper had reduced the range 5,000 yards. A most satisfactory method of remedying and of preventing this coppering, has been devised and used successfully in the French Army. This consists in introducing into the powder chamber a tin-lead alloy, which melts on firing and combines with the copper on the gun to form a brass, which no longer adheres as before to the interior of the bore. This process may be carried out best by attaching the alloy to the base of the projectile, by dipping, spraying with a metalizing pistol, or soldering on a disk of the metal. The introduction of foil of alloy into the powder bags appears to be satisfactory for small calibers, but does not give satisfactory results in large calibers.

611. Bursting and swelling of the tube are due to premature explosions of H. E. shells. French records show that such accidents occurred on an average of once in every 32,000 rounds with the 75's and once in every 14,200 rounds with the 155 Filloux guns. Such guns are usually discarded, but a process devised by Col. Canonica, of the Italian Army, is in use in Italy for reclaiming such material. This process consists of selecting two ruptured guns, in which the break is at different ends, cutting them in two and screwing the two good halves together. The threads are obtained by turning down the end of one part and boring out that of the other, each for about half the thickness of the metal and for 8 inches of length. Threads are cut very carefully so that the rifling matches when the two pieces are screwed home. Finally a ring is shrunk on outside the junction. This scheme has been used successfully on a considerable number of 149-millimeter cannon.

612. Wear, however, is the great and important problem in the maintenance of cannon. Care in cleaning of projectiles, faithful use of anticoppering methods, etc., may assist, but every gun will sooner or later wear so much that its range and accuracy are reduced below the economical limit. This wear occurs at the breech and muzzle ends principally, and consists in a gradual eating away of the rifling. At the breech end, this occurs more or less evenly around the circumference and is thought to be due to the intense heat of the burning powder gases which are projected against the forcing cone, as they follow the projectile. This wear causes the so-called "advance of the

forcing cone," i. e., the projectile must be pushed further and further toward the muzzle before it will seat properly in the rifling. The re- ult is an enlargement of the powder chamber, a change in the density loading, and a corresponding change and uncertainty as to muzzle ocity. The use of rifled projectiles, previously described, is de- d to eliminate the necessity for a forcing cone, to allow a powder ber the same size as the bore, and so to eliminate as much as of this wear. At the muzzle end, the wear is confined almost to the rear edge of the lands, the edge which does not press st the rotating band. It is thought to be due to the mechanical osion of the very high velocity gases which leak through the small orifice. This wear destroys the rifling progressively from the muzzle back to the breech and results in greater and greater dispersion of the shots.

613. The life of guns is given in a number of instances in the tabulated information of section 10. The figures there given for French guns in Volume II are from actual experience. From this experience the following formula for determining the life of large caliber guns has been developed:

$$\text{Life in rounds} = \frac{2.5 \times 10^7}{V^2 \times D \times (D-2)\ P^{1.7}}$$

where V = muzzle velocity in feet per second divided by 1,000.

D = caliber in inches.

P = maximum powder pressure in long tons per square inch.

The guns from which this formula was derived are nearly all very old models, and few, if any, had the advantage of the sort of care in firing that has now been discovered to be advisable. It is felt from isolated instances which have been compared with this formula, that a large gun operated with cleaned projectiles, and proper decoppering methods, should have a life at least 50 per cent in excess of that indicated by the above formula.

614. The methods available for the repair of worn-out guns are:

(*a*) Rechambering.
(*b*) Reboring.
(*c*) Relining.
(*d*) Retubing.

Rechambering consists of machining out the forward end of the powder chamber until the eroded metal is removed and a new forcing cone is formed. The piece is then supplied with a large powder charge, so arranged as to give the same muzzle velocity, and a considerable additional life, perhaps 40 per cent, may be obtained. This method is applicable only to guns, as they wear out at the breech end first, while howitzers wear about evenly at breech and muzzle ends. The advantages of this method are the simplicity with which it can be carried out and the very good results obtained. The disadvantages are the fact that it adds only fractionally to the life of the gun, that it is inapplicable to short pieces, and that it requires a special powder charge for such guns as are repaired by it.

615. Reboring consists of turning out the entire interior of the bore to a large diameter and rerifling. This necessitates the use of a different caliber of ammunition, and of a lower powder pressure and muzzle velocity, reducing the range, in some cases, materially. The life should be almost as many rounds at the new caliber as at the old. The advantages of this method are that no forging equipment or shrinking arrangements are necessary, and that the life of the gun is doubled. The disadvantages are the reduction in range and the necessity for using a different caliber of ammunition.

616. Relining consists of turning out the interior of the bore to a larger diameter and inserting a liner, in which the rifling of the original caliber is cut. This liner is usually inserted by shrinking the gun over it, but the method of autofrettage or expanding the liner into the gun by hydraulic pressure is also being developed. This method is probably inapplicable to small calibers on account of the thinness of the liner that would have to be used. The advantages of this method are that it requires a fairly light forging and that it gives a gun practically as good as new and using the same ammunition as the old one. The disadvantages are the forging facilities required, the length of the process, estimated as nearly 900 hours on the United States 12-inch gun, and the fact that there is considerable doubt about the possibility of rechambering relined guns.

617. Retubing consists of disassembling the gun and building it up again around a new tube, just as it was built up at first. This, of course, gives a gun in every way as good as new. The disadvantages are, of course, the great amount of forging and shrinking equipment required, and the length of the process.

618. Mounts.—Wear and tear on railway mounts are of the same character as take place on railway rolling stock and seacoast gun carriages. Breakages and derangements are of a purely mechanical character, and generally of fairly minor magnitude. Repairs require, principally, a well-equipped machine shop, and no detailed discussion of them is called for.

619. Organization and Arrangements for Maintenance.—In the British Army the maintenance shops for railway artillery were under the command of the ordnance officer at the base at Calais. In the French Army they were under the chief inspector of artillery, for fairly light repairs. Major repairs were made at the works of the Schneider and other private corporations. In the American Army the exact arrangement was never finally fixed, but to all intents and purposes, the repair shops for railway artillery were under the commanding general of the railway artillery reserve. It is felt, as a result of observations of the workings of these various systems, that

the shops should be directly under the control of the engineering division of the office of the chief ordnance officer. They should not, of course, be under the inspection service, but should be coordinate with it and under the same authority.

620. In the French Army most of the enlisted personnel required for the operation of the shops was assigned permanently and was not drawn from the various groups of artillery stationed near them. There were about 80 workmen permanently attached to the shops. These, with the four artificers attached to each battery, are easily able to handle the maintenance of not only all of the railway artillery of the French Army but likewise of a great amount of field artillery.

621. One feature which strikes one most forcibly in both the French and British repair shops is the evident skill of all the men. One does not see in any American shop the type of men used in these shops. The captains found in charge of all the shops were of the type of the highest caliber shop manager in America. These men are not only men of a great deal of shop experience, but high-grade graduate engineers. It is estimated that their average age is about 45 years. The use of such men as these in these positions is in the highest degree necessary.

622. Location and Equipment of Shops.—The scheme of disposition of inactive artillery just discussed makes the problem of maintenance a very easy one to solve in a very satisfactory fashion. In the yards of the camp where the railway artillery is mobilized, shops of the desired degree of permanency are built and equipped to handle all except the serious and most extensive of the maintenance work. Cars damaged very seriously by shell fire, or guns which must be relined or retubed must of course be sent back to the manufacturer or to the biggest base shop. In the French camp, the shops are well built brick structures of the type that one ordinarily finds used for medium heavy manufacturing. In the American camp the shop was similarly constructed, but was a steel frame building covered with corrugated iron.

623. The equipment of the French shops is about as follows:

- 2 24-inch lathes with 10-foot bed.
- 8 smaller lathes, about 12 by 72 inches.
- 2 horizontal milling machines.
- 4 shapers.
- 1 high-pressure air compressor for filling recuperator air bottles.
- 1 vertical boring mill.
- Oxyacetylene welding and cutting outfits.
- 3 large forges.
- Portable forges.
- 1 drop hammer.

1 portable air compressor for use with air tools.
1 circular saw.
2 band saws.
1 50-ton shop crane.
A good vise and bench for every man in the shop.

624. The equipment of the American shop was about as follows:

8 lathes, 8 by 12 inch swing.
1 lathe, watchmaker's.
6 grinders.
2 shapers.
5 drill presses, up to 20-inch radius.
3 screw machines.
1 planer, 8 to 12 foot bed.
1 power hacksaw.
1 power cold saw.
2 band saws.
1 Landis bolt machine.
2 300-foot air compressors.
1 welding and cutting outfit.
2 10-ton bridge cranes.

625. Experience with the American shop leads to the recommendation, slightly modified from that submitted by the commanding officer of the shop (38), that an equipment about as follows is necessary:

10 lathes, sizes from toolmaker's to 26-inch by 16-foot.
2 turret lathes.
1 planer, 48-inch by 16-foot.
2 shapers.
7 grinders, tool, cylinder and surface.
5 drill presses, 5-foot to high speed.
4 power saws, hack, cold and wood.
2 milling machines.
1 power hammer, 6-inch stroke.
1 heavy straightening press.
1 planer and joiner.
1 boring and mortising machine.
1 48-inch wood lathe.
1 brass cupola.
4 oxyacetylene cutting and welding outfits.
1 air compressor, 300 cubic feet, air tools.
1 150-ton bridge crane with 10-ton auxiliary.
1 10-ton high-speed crane.
1 150-ton locomotive crane.
1 15-ton locomotive crane.
1 4-foot bulldozer.
1 screw punch, 1-inch hole in ½-inch plate.
2 jib cranes, 2½ tons capacity.

626. With all these facilities provided, it has been found unnecessary to carry more than a few tools to the front with the mounts, i. e., anvil, portable forge, oxyacetylene outfit, hammers, chisels, brace and bits, drills, files, etc. No special repair car is employed in either the British or French armies, and neither organizations felt it to be advisable. A standard A. E. F. box car was fitted to serve as a repair car, plate 501, but the plan to provide them for service in France was abandoned. One was used to good advantage at the proving ground.

627. In the same way, practically all spare parts are carried at the shops in the main railway artillery camp or camps. The only spare parts carried with the mounts are for the firing mechanism, some bolts, screws, and miscellaneous stock. Such a car would be wasted unless the alterations or provisions made in it to carry spare parts would not interfere seriously with its use for something else. It surely would not be used to carry spare parts.

DUTIES OF THE RAILWAY ARTILLERY ORDNANCE OFFICER.

628. Although the following material, which was prepared by the writer, is given in another publication as noted above, it seems wise to give it here also in order that all material that has any reference to railway artillery may be contained in these two volumes. The following paragraphs will repeat information already given, but are included herein without modification just as they are given in the Ordnance Field Service Manual.

[Exact copy of Chapter X of Ordnance Field Service Manual (39).]

DUTIES OF THE RAILWAY ARTILLERY ORDNANCE OFFICER.

629. "Before proceeding with an enumeration of the duties of an ordnance officer of railway artillery, a brief explanation will be given of the organization and functions of what may be termed a "Railway Artillery Reserve," as it is at present understood.

630. Railway artillery in combatant service is quite analogous to the wrecking service of any railway organization. By this it is meant that although it is a definite part of the combatant organization as a whole, it is not a part and is not under the jurisdiction of the organization of any one army. The term "reserve" is used to imply that it is a branch of artillery not in use in daily routine service on the front, but is held in reserve at a central point for that peculiar and special type of work for which it has been designed and is peculiarly fitted. The point at which this artillery is held in reserve is known as the "Camp of the Railway Artillery Reserve," and may be considered to a certain extent in the light of a permanent camp. This camp accommodates during all of the time that it is not in active service not only the artillery itself, but the entire artillery personnel.

It includes, likewise, the heavy semipermanent railway artillery repair shop, general equipment, ammunition and spare parts depots, and a proving ground for the calibration of ammunition and proving of guns. The ammunition used by this artillery is not used by any other type of artillery, and it requires, in general, special facilities to handle it.

631. From the above brief explanation, it will be seen that the functions of the railway artillery ordnance officer are, as far as they concern the general equipment depots, quite analogous to those of a camp ordnance officer. The functions, with reference to the administration of an ammunition and spare part depot, ammunition inspection service, and artillery inspection service, are analogous to the functions of the Army ordnance officer. The functions with reference to the artillery maintenance service are peculiar to this type of service.

632. The railway artillery ordnance officer will be qualified as an adviser on all technical ordnance matters, including the effects of the various calibers and types of artillery for any specified work. Acting under the supervision of the proper staff sections, he is responsible for the efficient service of ordnance supply and maintenance, including inspection and repair work in the Railway Reserve, and supervises and coordinates this work. He exercises general supervision and control of all ordnance supply, repair, inspection and maintenance work, and facilities within the Railway Artillery Reserve in so far as technical matters are concerned, and is in direct control of supply, repair, inspection, and maintenance of the artillery. He makes, or causes to be made, such inspection of ordnance matériel and repair and maintenance facilities as he may consider necessary and permits no alterations in ordnance equipment without the authority of the chief ordnance officer, excepting in emergencies. He causes periodic inspection to be made of all storage facilities under his jurisdiction and sees that proper practice is observed in storage, particularly that ammunition is properly cared for and maintained, and that the necessary technical information is available.

633. He maintains such records as enable him to keep the commanding officer of the Railway Artillery Reserve fully informed as to the condition and sufficiency of ordnance matériel, all repair and maintenance facilities under his jurisdiction, and the condition of all ammunition. He makes such technical reports and keeps such records as are required of him by the commanding general of the Railway Artillery Reserve, by the chief ordnance officer, and by higher authorities. He is authorized to correspond directly with the chief ordnance officer on questions in which the policy of the Railway Artillery Reserve is not involved. He causes to be carried out such

technical instructions for repair, maintenance, and alteration of ordnance matériel as may be prescribed by the chief ordnance officer.

634. There are assigned to the railway artillery ordnance officer as assistants the following officers with their necessary commissioned and enlisted assistants for the operation of the services mentioned: Supply officer and artillery armament officer. The accompanying table shows the organization of railway artillery center for approximately 300 guns:

Ordnance personnel for railway artillery center for approximately 300 guns.

	1	2	3	4	5	6	7	8	9
			Supply warehouses.				Armament.		
1	Units.	Office of R.A.O.O.	Administrative office, 2.	General supplies, 2.	Artillery and parts, 2.	Ammunition, 3.	Inspection.	Maintenance Table Exhibit 1.	Totals.
2	Colonels	*1							1
3	Lieutenant colonels	*a 2							2
4	Majors						*b 2	1	3
5	Captains	*c 1	*c 1	e 1			3	1	7
6	First lieutenants			1	e 1	e 1	*1	2	6
7	Second lieutenants		1			1	*1	2	5
8	Total commissioned	4	2	2	1	2	*f 3	8	24
9	Ordnance sergeants	*h 1	2	2	1	2	*f 5	9	22
10	Sergeants, first class	*i 1		1	1	2			5
11	Sergeants		6	2	2	4	*g 3	25	42
12	Corporals	*j 2	3	4	4	10	42	31	58
13	Cooks			1	1	2		2	6
14	Privates, first class		2	5	5	10	42	48	74
15	Privates		4	20	10	50		16	100
16	Total enlisted	4	17	35	24	80	16	131	307
17	Aggregate	8	19	37	26	82	23	137	r 331
18	4 5-passenger cars.								
19	3 motor cycles with side cars.								
20	2 ¾-ton trucks.								
21	2 3-ton trucks.								

REFERENCES FOR PRECEDING TABLE.

[a] 1 artillery armament officer, 1 supply officer.
[b] 1 artillery inspector, 1 ammunition inspector.
[c] Administration assistant.
[d] 1 field inspector, 1 proof officer, 1 assistant to armament officer.
[e] In charge of sections.
[f] Technically trained assistant.
[g] Clerks.
[h] Chief clerk.
[i] Stenographer.
[j] Permanent personnel, clerks.
[1] Headquarters section and two platoons of an ordnance depot company.
[3] Two platoons of an ordnance ammunition company, Table 242.
[r] To be armed with rifles or pistols only when deemed necessary by commanding officers.

635. The administrative assistant in the office of the railway artillery ordnance officer is a captain. He is charged with the duties of maintaining the records of the entire ordnance personnel, both commissioned and enlisted, and with the proper keeping of office

records. He is authorized to make all emergency purchases, being appointed an agent officer for this purpose.

636. The supply branch is in charge of a lieutenant colonel, who is the supply officer of the Railway Artillery Reserve. He is charged with supplying equipment to troops and ammunition and spares for artillery. He requisitions for equipment, spares, and stock direct to the Chief of Ordnance of the Army if in the zone of the interior, or to the chief ordnance officer if in the theater of operations. He requisitions for equipment both regular and special in anticipation of demands to be made on his depot. He may requisition by telegraph when stores are urgently needed for the equipment of any troops, or the replacement of lost equipment, or for instruction purposes.

637. When an automatic supply of stores has been ordered in anticipation of the needs of the troops in the camp of the Railway Artillery Reserve, the supply officer keeps in touch with the supply and requests its expedition when necessity arises.

638. Supply officers of the various organizations located at the camp of the Railway Artillery Reserve requisition for items of ordnance property needed by the troops of their units, these requisitions having the approval of the organization commanders. These requests will be sent directly to the railway ordnance officer.

639. The supply officer has commissioned assistants in charge of administrative, general supplies, artillery and artillery parts, and ammunition sections.

640. The administrative assistant is charged with the account, and record work necessary in the office of the supply officer.

641. The officer in charge of the General Supply Section is charged with the receipt, storage, and issue of all ordnance stores except artillery and ammunition.

642. The officer in charge of the Artillery and Artillery Parts Section is charged with the receipt, storage, and issue of all material classed as railway artillery and spare parts thereof.

643. The officer in charge of the Ammunition Section is charged with the receipt, storage, and issue of all ammunition, including the loading of the special ammunition cars.

644. The assistants to the supply officer shall maintain such records as are necessary to keep the supply officer informed as to the stock on hand, the receipt, issue, and probable needs of general supplies, artillery and artillery spares, and ammunition. Similar blanks specified for the ammunition parks of the Army are to be used by the Ammunition Section.

645. The artillery armament officer is responsible for the inspection, repair, and maintenance duties in so far as they pertain to artillery and ammunition used by and in charge of the Railway Artillery

Reserve. He maintains such records as enable him to keep the railway artillery ordnance officer informed at all times as to the condition of all artillery, its availability for service, the state of the guns as to wear, etc. He will be prepared to furnish the railway artillery ordnance officer all necessary technical information on ammunition. He is personally responsible for the field inspection of all artillery. He specifies what repairs are to be made in the railway artillery repair shop or in the field and passes on their satisfactory completion. He will make periodic inspections of all artillery in the artillery park, will be responsible for the condemnation of guns unserviceable from wear or accidental damage, and will see that all field organizations are instructed on the proper use and care of their material. He is likewise charged with the administration of maintenance facilities shops, etc., provided for such work as is hereinafter specified.

646. Inspection shall be made of all artillery at least eight or ten times during its normal life. This inspection will consist of a visual examination of the bores for coppering, pastilles, cracks, or other injuries, the operation of the elevating, traversing and breech mechanisms, and the accuracy of the sighting mechanisms; it will also include the questioning of the battery mechanics regarding the operation of the recoil systems and the length of time between the renewals of the recoil fluid and examination of the gun books.

647. A star gauge and a plug gauge record should be made at least two or three times during the life of the gun, and gutta percha impressions of any abnormal conditions, such as excessive wear, unnatural erosion or swells.

648. The artillery inspector will make a final inspection of all repairs made in the artillery repair shop and is responsible to the artillery armament officer that all field and shop repairs and maintenance are properly executed. He maintains such records with reference to the condition of each individual gun, carriage, etc., as enable him to inform the artillery armament officer of its exact status with reference to its availability for service, the remaining life of the gun, and of the characteristic field behavior of the gun and carriage. He will supervise the proving of guns and carriages, the firing of range tables, and the proving of improvised artillery accessories. He will investigate and report upon all accidents chargeable to defects in the artillery material. It is his responsibility to see that all technical investigation called for by the chief ordnance officer with reference to the behavior of the guns and carriages are properly carried out, and he shall maintain his routine records with such thoroughness and exactness as will assist to the maximum services responsible for the design of the material.

649. The artillery inspector will be provided with one closed car for field inspection service and one light repair truck for carrying of

inspection instruments. He will be provided with the following miscellaneous equipment:

Star gauges suitable for the various calibers of guns.
Plug gauges.
Bore sights.
Gutta percha impression outfits.
Alidade.
Planimeter.
Steel tapes.
Micrometers.
One complete set of drawing instruments, including Universal drawing instruments.
Flexible curve.
Complete set of Universal curves.

650. The ammunition inspector is responsible for the inspection of all ammunition, storage and handling facilities, and will see that safety instructions are complied with. He will make periodic examinations of the condition of ammunition both by visual inspection in the storage house and by trial on the proving ground. He is responsible for the furnishing of all technical information on ammunition, both to the troops and to the artillery armament officer. He will investigate and report upon all accidents that may be chargeable to ammunition, and will keep the artillery armament officer informed as to the behavior of ammunition and any defects discovered. He is responsible for the calibration of all ammunition as called for by the commanding officer, Railway Artillery Reserve. He is responsible for the collection, examination, and report on specimens of captured or unexploded enemy ammunition. He shall maintain such records as will be of maximum service to those organizations responsible for the design and manufacture of ammunition and he will conduct such investigations as may be called for by the chief ordnance officer. He will be provided with a full set of drawing equipment, Ideal drawing instruments, flexible curve and Universal curves and beam compass.

651. The railway artillery maintenance officer is in charge of the special railway repair shop and handles all necessary repairs and general maintenance on all artillery and motor vehicles. He supervises the making of all modifications in artillery as specified by the chief ordnance officer or required by field emergencies. He is responsible for the maintenance of such records as enable him to keep the artillery armament officer informed as to the condition and adequacy of all his facilities and the supply officer as to his needs for spare parts and raw materials. He is responsible for the making up of any necessary designs for emergency equipment or replacements. He shall maintain such records as will be of maximum assistance to

the various ordnance design services with reference to the performance of the various designs of mechanisms and the materials used therein.

652. Since the personnel of the railway artillery repair shop is responsible for the maintenance of all artillery, it is the duty of the maintenance officer to take under his charge the special mechanics assigned to each battery while the artillery organizations are in the park. These men will be used in the general maintenance service and will be given such training as will enable them to properly maintain their artillery in the field.

SECTION 8.

EQUIPMENT FOR RAILWAY ARTILLERY.

653. Tables of Initial Equipment.—It is not intended in the following to attempt to give definite rules for what should constitute total accessory equipment for railway artillery. Certain general recommendations will be made, however, which are based on French and British experience and observations by members of the Ordnance Department in France. It is probable that these will be of some value in the future (40).

654. A definite understanding was never reached between the Ordnance Department in France and the Ordnance Department in Washington with reference to the lists of equipment prepared in France for the American Railway Artillery. The Engineering Division of the Ordnance Department in France prepared lists which included primarily items of equipment in use by the French and British services, but which, due to different service conditions, were not familiar to the Ordnance Department in Washington. In addition, an attempt was made to complete the lists as nearly as possible from the information received from Washington on drawings, tables of equipment, etc. Only incomplete information had been received at the time, however, with reference to the requirements for the 8-inch gun and 12-inch mortar, for which the tables were being made. The lists were consequently not considered complete, but were nevertheless forwarded to Washington. It seems that this procedure led to some misunderstanding; e. g., items which had been left out for the lack of sufficient information were, when the lists were gone over in Washington, assumed as not wanted. It was hoped that, by combining the ideas of requirements as contained in the lists prepared in France, and the requirements necessitated by the particular type of mount worked up in Washington, at least sufficient equipment would be provided. The lists as they were prepared in France covered only the initial battery equipment, to a large extent based on the equipment carried by the French batteries.

655. Depot and Automatic Supply.—Neither the experience of the French nor the British service was sufficiently extensive to enable one to establish figures with reference to depot supply and

automatic supply. For this reason, and in order that an ample initial supply might be furnished, the arbitrary amount of one complete battery equipment for each three batteries was requested for the initial depot supply. It was intended that after sufficient knowledge had been gained with reference to rate of consumption, certain items could be put on an automatic supply list. It was feared that an arbitrary assumption of figures for automatic supply would lead either to an excessive accumulation of certain articles, or to the supplying of insufficient quantities of other items. To date no further knowledge has of course been gained on this subject, so it is impossible to give any figures covering either the number of parts to be kept on hand in a depot, or to be supplied automatically. A close study of each particular mount in the design office will lead to fairly reasonable assumptions for requirements of spare parts. In determining numbers of spare parts, it is certain that destruction of parts by shell fire need not be considered.

656. Spare Parts, Tools, and Accessories Carried with the Battery.—Assuming that the railway artillery is operated from one or more large camps or centers which are equipped to handle all repairs except relining or reboring of guns, and extensive rebuilding of damaged carriages, and assuming also that the radius of operation is such that for any medium repair work not necessitating the withdrawal of the mounts to the shop, they can be reached by a mobile repair truck within a reasonable time, it is evident that only a very limited supply of spare parts need be carried with the battery. It is also evident that only a limited number of ordinary repair tools would be required.

657. The system of operating railway artillery from one large center is well established and highly recommended. The scheme of handling medium repair work with repair trucks, while not tried out to any great extent in connection with railway artillery, nevertheless seems to have many advantages. First, as mentioned above, the quantity of repair tools and spares carried in the field with the mounts can be considerably reduced; second, the number of skilled mechanics can be limited to a great extent and utilized to much better advantage on repair trucks and in the repair shops than they would be if permanently assigned to a battery. The tables of organization for railway artillery provide 28 enlisted ordnance men per regiment of 24 guns. As railway artillery never operates in units of regiments, these men, if kept with the guns, must be divided between the six batteries. This of course results in an uneven distribution of skilled and unskilled men. If, instead, the men are kept at the shop which is provided with a sufficient number of repair trucks, supply trucks, good automobiles and motor cycles, it is obvious that any S. O. S. call from the front for repairs and spare

parts can be answered by picked men for the particular kind of repairs required, and the best results obtained in the same or less time. It is thought that one repair truck per group of eight guns would be required on an active front. This discussion is largely on maintenance, but it is evident that the quantity of equipment which should be carried is a direct function of the scheme of maintenance employed. Assuming that the repair-truck scheme is adopted, the following recommendations for equipment to be carried in the field are made. As the equipment will of course vary with the type of mounts, the recommendations must be considered very general.

658. TOOLS AND ACCESSORIES RECOMMENDED—

A. Tools and material required to make emergency track repairs:
1. Standard track tools.
2. A few pieces of rail, bolts, spikes, and fishplates.
3. A few standard ties.

B. Tools and accessories for operating train:
1. Lantern, lamps, flags, etc.
2. Car pusher and replacer.

C. Tools, accessories, and material for emplacement.

This will, of course, vary with the different types of mounts and can very easily be determined. The material and items constituting platforms, outriggers, etc., should be ample in regard to spares if easily broken or damaged.

D. Tools, accessories, and parts for gun and breech.

In determining the spare parts to be carried with the gun in the field, it should be kept in mind that only such parts as can be easily replaced should be considered; as, for instance, firing mechanism and firing pins, a few extra bolts and nuts, washers, packing, springs, cotterpins, etc. It should also be kept in mind that, besides adding to the weight which is hauled around unnecessarily, a good deal of time is consumed in taking care of parts which seldom will be required, and could better be cared for in the depot.

E. Tools, accessories, and spare parts for carriage and mount.

The statement made under D applies to this section. Such articles as journal bearings, brake shoes, air-brake hose, brake pins, and cotter pins should be carried in small quantities. It does not seem necessary to carry spare couplers and buffers, however, it may be advisable to carry a limited number of emergency knuckles.

F. Jacks, cordage, blocks, etc.

Only such jacks should be carried as demanded by anticipated difficulties, as, for instance, the need of auxiliary jacks for raising the car for the 12-inch mortar. A good supply, about 200 feet per gun, of 1½-inch rope and about 200 feet of ½-inch rope should be kept on hand, and two sets of double tackle blocks for 1½-inch rope. One spare triplex block with chain of capacity used for loading cranes. Twine packing and whipping and tarred hemp yarn, ½-inch, should be carried in ample quantities.

G. Carpenters' tools:

	Per battery.
Axe	1
Augurs—	
Screw, solid, wing-eyed, 1½-inch	1
Screw, solid, wing-eyed, 1-inch	1

G. Carpenters' tools—Continued.	
Bits, twist—	
1-inch	1
¾-inch	1
½-inch	1
¼-inch	1
Brace, ratchet, for bits	1
Chest, tool, carpenter's	1
Chisel, wood—	
1½-inch	1
1-inch	1
½-inch	1
Mortising	1
Gouge, ½-inch	1
Gouge, 1-inch	1
Dividers, 8-inch	1
Drift, steel, round, ½-inch	1
Gimlet—	
¼-inch	1
⅛-inch	1
Hammer, claw	1
Handles—	
Augur, 16-inch	1
Saw, crosscut	1
Hatchet, wood handled	1
Mallet	1
Oil stone, ¼ by 2 by 8 inches	1
Pencils, carpenter's	1
Pinchers, pair	1
Plane, jack	1
Rasp, wood—	
Flat	1
Round	1
Rules, folding, 6-foot	1
Saw—	
Hand, rip, 36-inch	1
Hand, crosscut, 26-inch	1
Blade, 5-foot, with handles	1
Square, combination, 8-inch blade	1
H. Machinists' tools:	
Chest, tool, machinists'	1
Chisel—	
Cape, steel	1
Cold	1
Dividers, spring nut, 6-inch, pair	1
Drill, breast, with chuck	1
Drill, twist, straight shank, Morse original, for breast drill—	
⅜-inch	1
5/16-inch	1
¼-inch	1
3/16-inch	1
⅛-inch	1
3/32-inch	1

H. Machinists' tools—Continued.	
Drill, ratchet	1
Drills, for ratchet drill, twist	1
$\frac{1}{2}$-inch	1
$\frac{5}{8}$-inch	1
$\frac{3}{4}$-inch	1
1-inch	1
Emery stick, fine	1
Files—	
Flat bastard, 12-inch	1
Round bastard, 12-inch	1
Square bastard, 12-inch	1
Flat, second cut, 10-inch	1
Round, smooth, 10-inch	1
Square, smooth, 10-inch	1
Taper, 8-inch	1
Hammer, machinist, ball pein, $1\frac{3}{4}$ pounds	1
Handles, file, assorted	12
Jaws, copper, for bench vise, pair	1
Oiler, machinist's, small	1
Pin, drift, $1\frac{1}{4}$ by 1 inch	1
Punch, center	1
Saw, hack, adjustable	2
Saw, hack, 12-inch blades	36
Scale, steel, square combination	1
Vise, bench, about 4-inch jaw	1
Wrenches, monkey—	
6-inch	1
12-inch	1
18-inch	1
I. Blacksmith's tools:	
Anvil, 100 pounds	1
Borax, pounds	1
Chisel, hot, 2-inch blade	2
Forge, portable, "Buffalo," 24 by 30 inches, with tank	1
Hammer, blacksmith's, $1\frac{3}{4}$ pounds, with handle	1
Hammer—	
Sledge, 10 pound, with handle	1
Set, $1\frac{1}{2}$ pounds, with handle	1
Hardie, 2-inch blade, 1-inch handle	1
Punches, blacksmith's—	
$\frac{3}{8}$-inch	1
$\frac{1}{2}$-inch	1
Swages, pair—	
$\frac{1}{2}$-inch	1
$\frac{3}{4}$-inch	1
1-inch	1
$1\frac{1}{2}$-inch	1
Tongs, blacksmith's, pair—	
$\frac{1}{2}$-inch	1
1-inch	1
$1\frac{1}{2}$-inch	1

J. Tinner's tools and supplies:

Acid, muriatic, pint	1
Sheet zinc, ounce	8
Blow torch	1
Iron, soldering, with handle, pounds	1
Mallet trimmers	1
Sal ammoniac, lump, pounds	1
Snips, tinners'—	
Large, pair	1
Small, pair	1
Solder, soft, pounds	4
Zinc, alloy, for brazing, pounds	4

K. Miscellaneous tools and accessories:

Buckets, water	As required.
Cans	As required.
Emery wheel, hand	1
Extinguisher, fire	1 for each box car and mount.
Machine spike, steel, 11-inch	1
Needles, sail	4
Palms, sewing, leather	1
Wrench, Stillson pipe, 14-inch	1

L. Miscellaneous material for repair:

Bolts and nuts, assorted.	
Round iron—	
¼-inch by 5-foot pieces	2
½-inch by 5-foot pieces	2
1-inch by 5-foot pieces	2
Nails, assorted, pounds	30
Pins, cotter, assorted	30
Rivets—	
¼ by 1 inch	50
⅜ by 1½ inch	50
½ by 2 inch	50
⅝ by 2½ inch	50
Screws—	
Machine, assorted.	
Wood, assorted.	

Steel angles, bar, plates, etc., should be carried in small quantities and as required.

M. Fire-control equipment:

Protractors in decigrades	2
Protractors in mils	1
Scale 1/20000	2
Scale 1/50000	2
Scale 1/80000	2
Double decimeter scale	2
Case of drawing instruments	2
Drawing boards	2
Pocket compass	2
Battery telescope and tripod	1
Siege telescope with tripod	1
Surveyor's chain with markers 20 meters	1
Steel tape 10 meters with markers	1
Logarithmic tables in degrees and grads	2

M. Fire-control equipment—Continued.

Drawing board 28 by 28 inches	2
Alidade with level	1
Alidade with telescope	1
Straightedge ruler	2
Triangles 60 degrees	2
Triangles 45 degrees	2
Large board (28 by 28 inches) squared	1
Zinc sheets, squared	1
Drawing pencils, No. 3	25
Erasers, rubber	6
Paper, drawing, rolls	6
Tracing paper, rolls	6
Red ink, bottles	3
India ink, bottles	3
Theodolite	1
Barometer, aneroid, metric	1
Compass declinator	1
Thermometer (Centigrade)	2
Field glasses, prismatic, type E. E., Signal Corps	2
Slide rule or omnimeter	2
Sighting rod	1
Wooden stakes	6

SECTION 9.

SUMMARY OF RECOMMENDATIONS.

659. The following is a summary of the recommendations made in the previous pages in regard to railway artillery for the United States Army:

660. GUNS.—It is recommended:

A. That the Railway Artillery Program include the following guns:

12-inch, 25-caliber howitzer.
16-inch, 25-caliber howitzer.
10-inch, 50-caliber gun.
14-inch, 50-caliber gun.

661. MOUNTS.—It is recommended:

A. That the 12-inch howitzer be mounted either on the same carriage recommended for the 10-inch gun below or on a carriage of characteristics similar to those of the carriage already developed for the 12-inch, 20-caliber howitzer, plate 194.

B. That the 16-inch howitzer be mounted on a combined sliding, rolling, and quick emplacing carriage, embodying the sliding recoil features of the 14-inch model E carriage, the rolling recoil features of the 16-inch model 1918 carriage, and the quick emplacing features of the 8-inch carriage (outrigger) and 280-millimeter German carriage (pedestal), if practicable, or the base ring of the 14-inch model E if the German pedestal is impracticable.

C. That the 10-inch, 50-caliber gun be mounted similarly to the German 280-millimeter, but with modifications, plate 59, to allow firing from the wheels for limited fire and quick emplacement for wide-angle fire.

D. That the 14-inch, 50-caliber gun be mounted on the same carriage recommended for the 16-inch howitzer above.

662. EQUIPMENT.—It is recommended:

A. That spare-parts cars be not furnished, and that equipment in general be supplied in accordance with the recommendations given in section 8.

663. SHOPS—MAINTENANCE.—It is recommended:

A. That shops in every case be established at the railway artillery camp to handle maintenance of all such artillery. In the interest of hasty evacuation with minimum loss, should such evacuation become necessary, it is recommended that the shop be of the semiportable type.

B. That shop equipment be provided in accordance with the recommendations of section 7.

C. That special attention be given to the obtaining of officers of long experience and special ability in shop practice for the supervision and operation of these shops.

D. That special attention be given to obtaining several officers and a number of men who are thoroughly familiar with the commercial railway companies' methods of maintaining standard rolling stock. Further, that some of these officers and men be retained for peacetime service. In the event that this is not possible, it is recommended that several C. A. C. officers and a number of men be detailed for a time to the maintenance service of some railroad company in order that they may become familiar with the difficulties experienced and the routine and emergency measures applied.

SECTION 10.

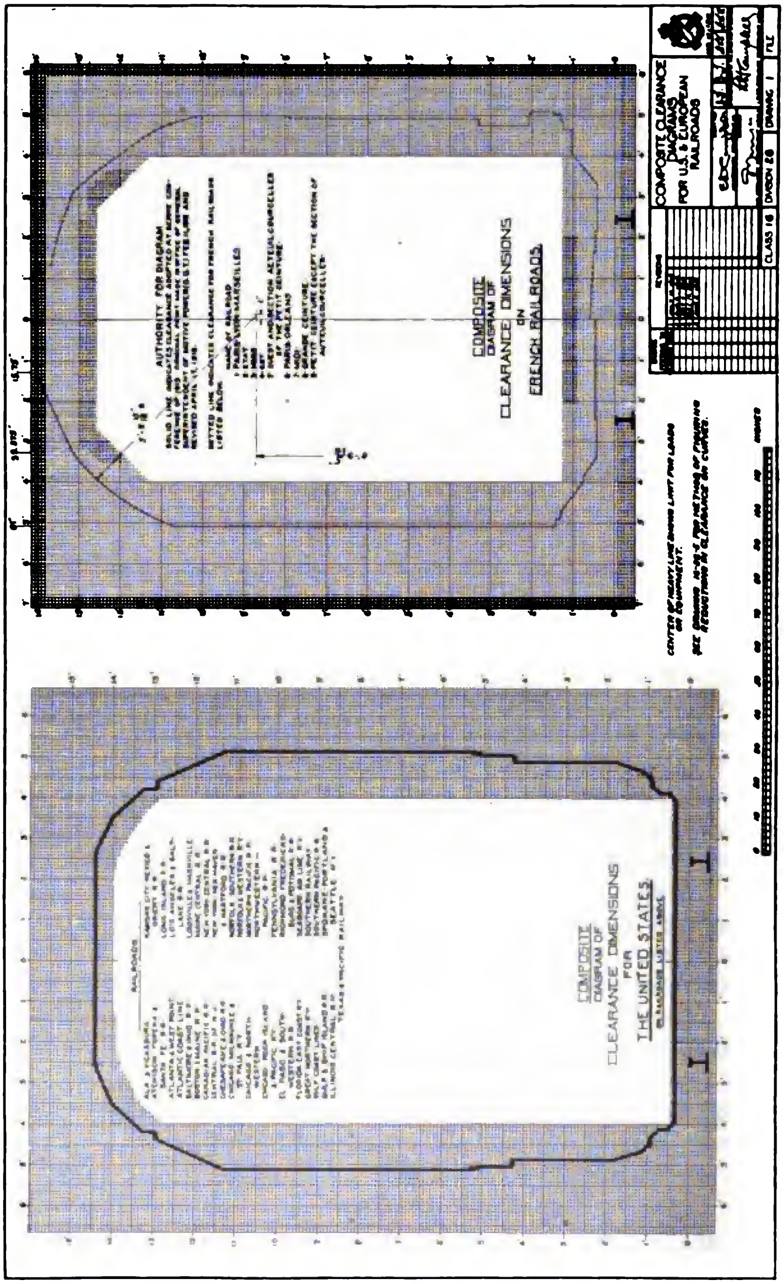
RAILWAY CLEARANCES AND TABLES OF CLASSIFIED INFORMATION.

664. Railway Clearances (41).—In order that the material contained in this report may be complete from the standpoint of all who are interested in any phase of railway artillery, it seems wise to include a discussion on railway clearances. The discussion given in the following paragraphs is based on a handbook on clearances, prepared in the Railway and Seacoast Carriage Section of the Ordnance Department, and with which the writer has had some connection. In the handbook referred to, individual maps and clearance diagrams are given for each of the roads listed on plate 481. A key map is given likewise of all those main lines represented by these roads and over which the railway artillery would be transported, east, west, north, and south, and along the coasts and borders, in the event of an emergency. There are too many individual maps and clearance diagrams to include in this work and it seems best to omit the key map, since this volume is for general distribution.

665. Composite Diagram for American Railways.—The composite clearance diagram of railways may be termed an outline or diagram of such shape and dimensions that when the transverse section of the various railway vehicles remain within its limits, these vehicles can be transported over all sections of the roads concerned with a predetermined clearance from obstructions, so long as the distance between the truck centers of these vehicles is kept within certain specified limits. Such a composite clearance diagram of railroads is perhaps an indefinite outline unless full explanation is given as to what it covers. The diagram shown on plate 481 covers all American railroads listed thereon. These roads include all coastal lines, Mexican border lines, some transcontinental lines, and a few central, north, and south lines.

666. The information from which the clearances were drawn was obtained direct from the chief engineer's office of each railroad. From this information a composite diagram was then drawn for individual railroads. These composites were then compiled into a master composite diagram. The clearance information obtained showed either actual obstructions or clearance limits with an allowance of 4 inches between the clearance line and actual obstructions. The composite clearance diagrams allow 4 inches clearance between actual obstructions and the outline.

Plate 481


COMPOSITE DIAGRAM OF CLEARANCE DIMENSIONS ON FRENCH RAILROADS
COMPOSITE DIAGRAM OF CLEARANCE DIMENSIONS FOR THE UNITED STATES
COMPOSITE CLEARANCE DIAGRAMS FOR U.S. & EUROPEAN RAILROADS

667. The diagram makes no allowance for curves, but it is safe for equipment whose truck centers do not exceed 40 feet. On railway mounts whose trucks centers exceed this dimension, allowance must be made for the overhang of the mount in rounding curves. It is safe to figure a maximum curve of 17 degrees, 337 feet radius, on the main lines of railroads shown. Hence, the width of the mount will be reduced at least as much as the computed off-set on a 17-degree curve. A full discussion of railroad curves will be given later.

668. It was early recognized that to compile a clearance diagram of every railroad system in the country would be an endless and indeterminate task as well as being worthless when completed. The futility of attempting to establish such an absolute clearance diagram of every road is best illustrated by the following facts: There are over 250,000 miles of railroads in America. Some of these roads are inaccessible to any but the lightest railway equipment and are located in the interior mountainous regions. For instance, some standard gauge railroads are used only by the lumber interests. Special logging cars and locomotives comprise the rolling stock of these roads. Obviously no piece of railway artillery could ever be transported over such tracks. Such roads would therefore be useless for railway artillery shipments and have not been considered.

669. Other railroads, while using standard equipment, touch only the small central and western interior towns. These roads are generally branches of the larger systems and it is improbable that any emergency could ever arise for their use. If it did, the branches would have to be rebuilt. These roads are not considered on the diagram.

670. To compile a maximum clearance diagram of all the big railroad systems of the country would result in such limitation of dimensions of the railway mount that one could not use it for the design of the heavier caliber guns. The branch lines of some of these systems present limitations that sometimes interfere with their standard equipment, but the territory covered is so important that lighter rolling stock is used. Hence it would be unwise to limit the diagram by including all branch lines of the big systems. Some of the branch lines, however, are of vital importance and these have been included. If it is not possible to reach an important point from one line on account of some limiting feature, it has generally been found possible to detour to that point.

671. It must not be presumed from this discussion that railway clearances can be compiled into a fixed outline or diagram. The more progressive railroad companies are constantly changing their clearances and improving their curves. So to keep up to date, it is necessary to keep in touch with the railroad engineers. These changes should be checked up every six months and the diagrams changed if affected.

672. Method of Using American Composite Diagram.—The master composite clearance diagram shown on plate 481 is complete for all the railroads listed thereon. As previously stated, the clearance outline shown is 4 inches within the actual obstruction line. In using this diagram the matter given later under the headings of "Railroad curves," "Offset of middle ordinate," and "Elevation of outer rail on curves" must be carefully considered. In other words, the outline of the railway mount or equipment considered must not only come within the diagram, but if the truck centers are greater than 40 feet, allowance must be made for the three items just mentioned. The method of computing these allowances is given under the proper heading, and these dimensions must be deducted from the clearance outline shown on this American clearance diagram. All of this is true only in the event that the truck center distance of the equipment is greater than 30 feet. It is impossible to state absolutely the degree of curvature of all lines covered by this diagram. It is a safe assumption to state that the maximum curve over any road on which railway mounts are liable to be run is approximately 17 degrees. The radius of this curve is 337 feet.

673. The middle ordinate or overhang at the center of equipment whose truck centers are 30 feet on the 17-degree curve is 4 inches, as determined by the formula given under paragraph 682 on middle ordinate of curves. It is readily seen that this offset enters into the calculations in determining the extreme width of the railway mount.

674. The elevation of the outer rail on curves does not present such limitation to the width of railway artillery as might be supposed, for the reason that the extreme width of railway artillery mounts at or near the maximum height is generally less than the clearance diagram. Since the elevation of the outer rail affects the width a perceptible amount only at its extreme height, it is evident that there is ample room between the outlines of the mount and the upper portion of the clearance diagram. The contour of the railway mount will, however, determine this feature.

675. On such equipment as the ammunition cars this elevation of the outer rail is of extreme importance, since the car has its extreme width at the height of the eaves of the roof.

676. Composite Diagrams A and B.—For ready reference in looking up limiting features of the American composite clearance diagram, diagrams A and B are given as covered on plates 503 and 504, respectively. The limiting features and the railroads on which these occur are shown on these diagrams together with actual dimensions above the rail. The two diagrams are, of course, covered by the master clearance diagram, and are only included for the detailed information which they contain. These two diagrams are to be

used in the same manner as the master composite diagram and the full line on each one indicates 4 inches actual clearance inside of the obstruction line.

677. FRENCH RAILWAY DIAGRAMS.—As the Ordnance Department was shipping railway mounts to France, it was vitally interested in the clearances of railroads in that country. Accordingly, information was secured which enabled the section to draw the French composite clearance diagram. This was placed on the same tracing as the American composite, for it was of vital interest. It is practically the same diagram as was being used by the officer of the Director General of Military Railways in designing railway equipment for use in France. This diagram was based on proceedings of the International Conference at Berne in the year 1913. No map was prepared for this European clearance diagram.

678. The railroads in France do not report exactly the same clearances as shown on the Berne conference diagram. It was, therefore, decided to split the European composite diagram in two (pl. 484). That part of the diagram on the left of the center line represents the "Passe-Partout" or Berne conference clearance diagram, and the part on the right of the center line represents a composite of nine French railroads. A table of clearance for European railways is given on plate 485.

679. CURVES—MIDDLE ORDINATE.—All of the American diagrams were worked out on the basis of having 4 inches between the clearance line and the actual obstruction. On straight-line tracks and on curves of large radii, this is sufficient for mounts whose truck centers do not exceed 40 feet. When the truck centers exceed this distance additional side clearance is necessary. The two components of the element of side clearance in rounding curves are the overhang of the mount and the elevation of the outer rail. Before taking up these two features, it may be profitable to fix in one's mind the meaning of the accepted manner of expressing the amount of curvature of a railroad track. Curves on a railroad are usually expressed in degrees and minutes. This degree in this country means the central angle subtended by a chord 100 feet long. Approximately 1 degree of curvature is equivalent to a radius of 5,730 feet. Thus:

$$5{,}730 \times 2 \times 3.1416 = 360 \times 100$$

$$36{,}001.7 = 36{,}000$$

Hence, to obtain the radius of a curve in feet, divide 5,730 by the number of degrees of curvature.

680. In the metric system, instead of the chord being 100 feet, it is 20 meters or 65.61 feet. So with the central angle remaining the same, the radius will necessarily be less. This can be represented

by 65.61/100 for a 1 degree curve, or approximately 5/8 English measurement. Thus—

$$10 \text{ degree curves} = \frac{5730}{10} = 573 \text{ feet radius, American, fig. 1.}$$

$$10 \text{ degree curves} = \frac{65.61}{100} \times \frac{5730}{10} = 375.9 \text{ feet radius, French, figure 2,}$$
plate 487.

681. The middle ordinate distance must be subtracted from the width when it is sufficiently large to come within clearance limits. In other words, the diagrams allow clearance only for equipment having truck centers less than 30 feet, and when this is exceeded, the width of the mount must be decreased by the number of inches of overhang.

682. **Overhang.**—The overhang at the center of a car will be the same as the middle ordinate of the chord whose length is the distance between truck centers, figure 3, plate 487. This distance may be obtained by laying out the truck centers on a curve of given radius or from the approximate formula—

$d = \dfrac{c^2}{8R}$ used, where

R = radius to center of track
c = truck center distance
d = middle ordinate.

In the event that the mount is equipped with span bolsters an additional (d) will have to be figured, fig. 4, plate 487. Thus—

$$d = \frac{c^2}{8R}$$

$$d' = \frac{c'^2}{8R}$$

$$R' = R - d'$$

683. **Super-Elevation.**—The super-elevation of the outer rail on curves will, of course, decrease the clearance. The amount of this super-elevation is a function of the train speed and the degree of curvature. An empirical formula for finding the elevation which gives results sufficiently close is—

$E = .000685S^2D$, where

E = Elevation of outer rail in inches.
S = Speed in miles per hour.
D = Degrees of curvature.

Example for 10 degree curve.

$$E = .000685 \times 30^2 \times 10$$
$$E = 6.165 \text{ inches.}$$

(Taken from American Locomotive Co.'s Handbook.)

PLATE 482

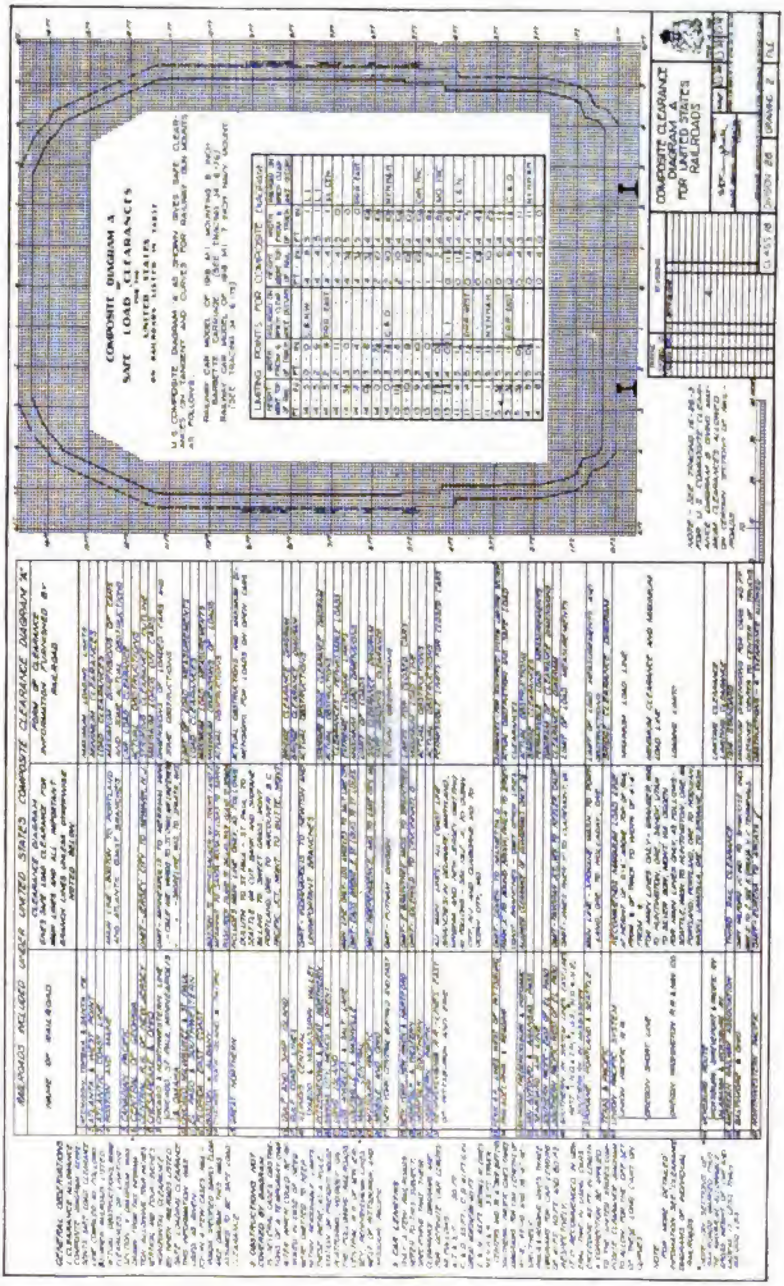

COMPOSITE DIAGRAM A
SAFE LOAD CLEARANCES
COMPOSITE CLEARANCE DIAGRAM A FOR UNITED STATES RAILROADS

PLATE 483

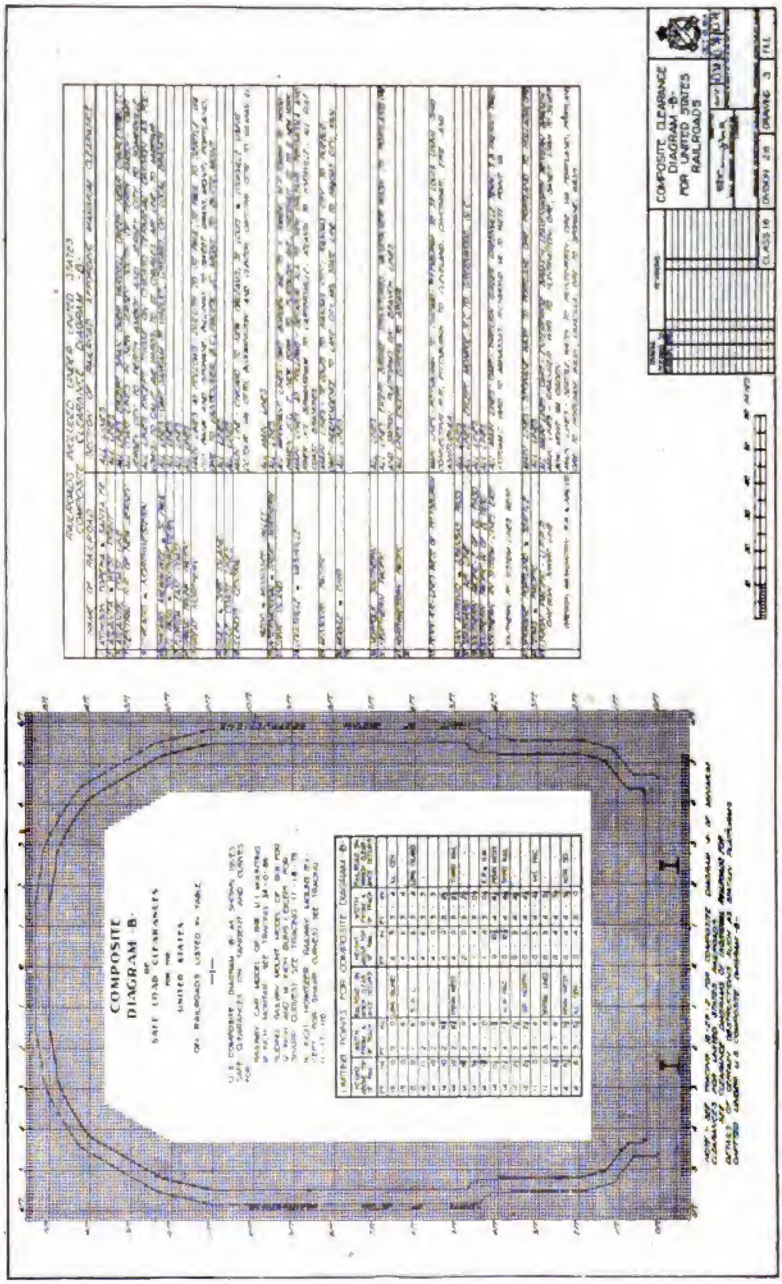

COMPOSITE DIAGRAM -B-
COMPOSITE CLEARANCE DIAGRAM -B- FOR UNITED STATES RAILROADS

Plate 484

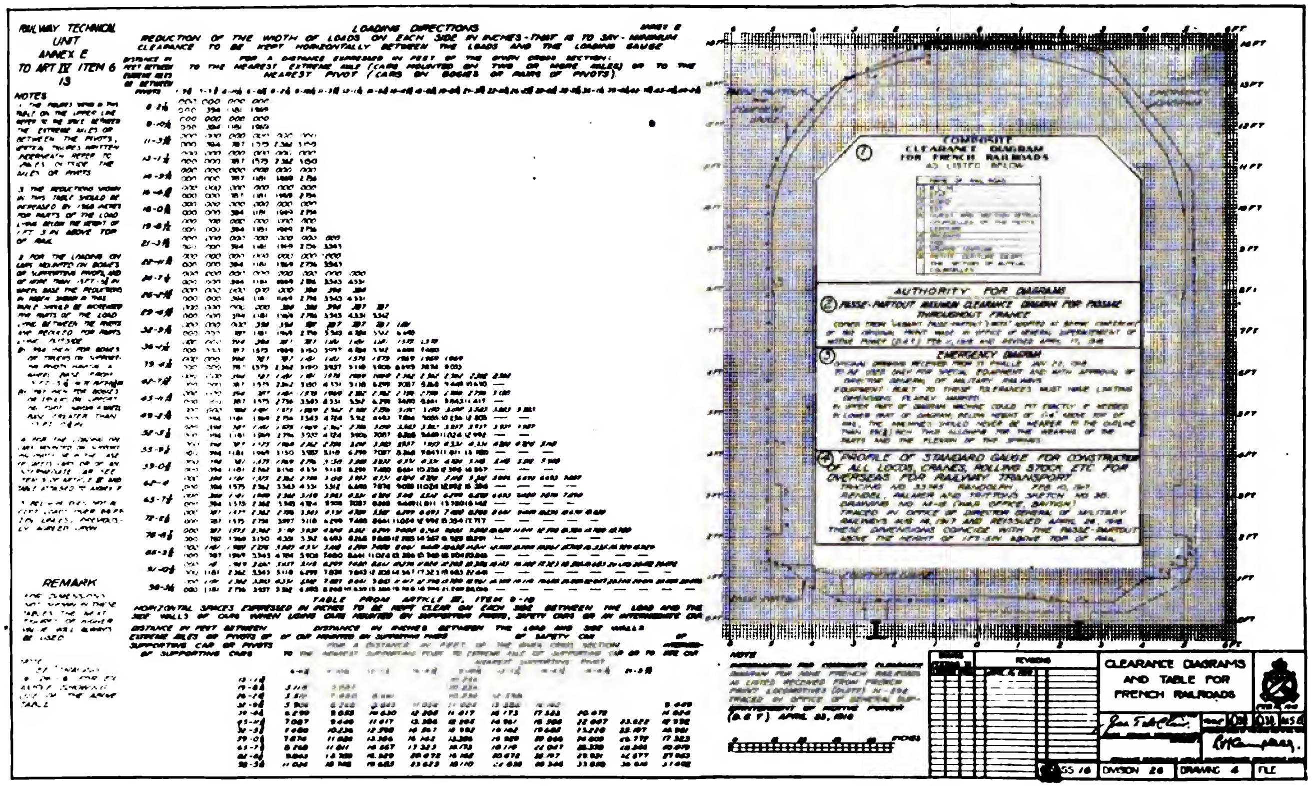

RAILWAY TECHNICAL UNIT
ANNEX E
TO ART IV ITEM 6
13
LOADING DIRECTIONS
REDUCTION OF THE WIDTH OF LOADS ON EACH SIDE IN INCHES - THAT IS TO SAY - MINIMUM CLEARANCE TO BE KEPT HORIZONTALLY BETWEEN THE LOADS AND THE LOADING GAUGE
NOTES
REMARK
TABLE FROM ARTICLE III, ITEM 9-10
COMPOSITE CLEARANCE DIAGRAM FOR FRENCH RAILROADS AS LISTED BELOW
AUTHORITY FOR DIAGRAMS
EMERGENCY DIAGRAM
PROFILE OF STANDARD GAUGE FOR CONSTRUCTION OF ALL LOCOS, CRANES, ROLLING STOCK ETC. FOR OVERSEAS FOR RAILWAY TRANSPORT
CLEARANCE DIAGRAMS AND TABLE FOR FRENCH RAILROADS
DIVISION 26
DRAWING 4
FILE

PLATE 485

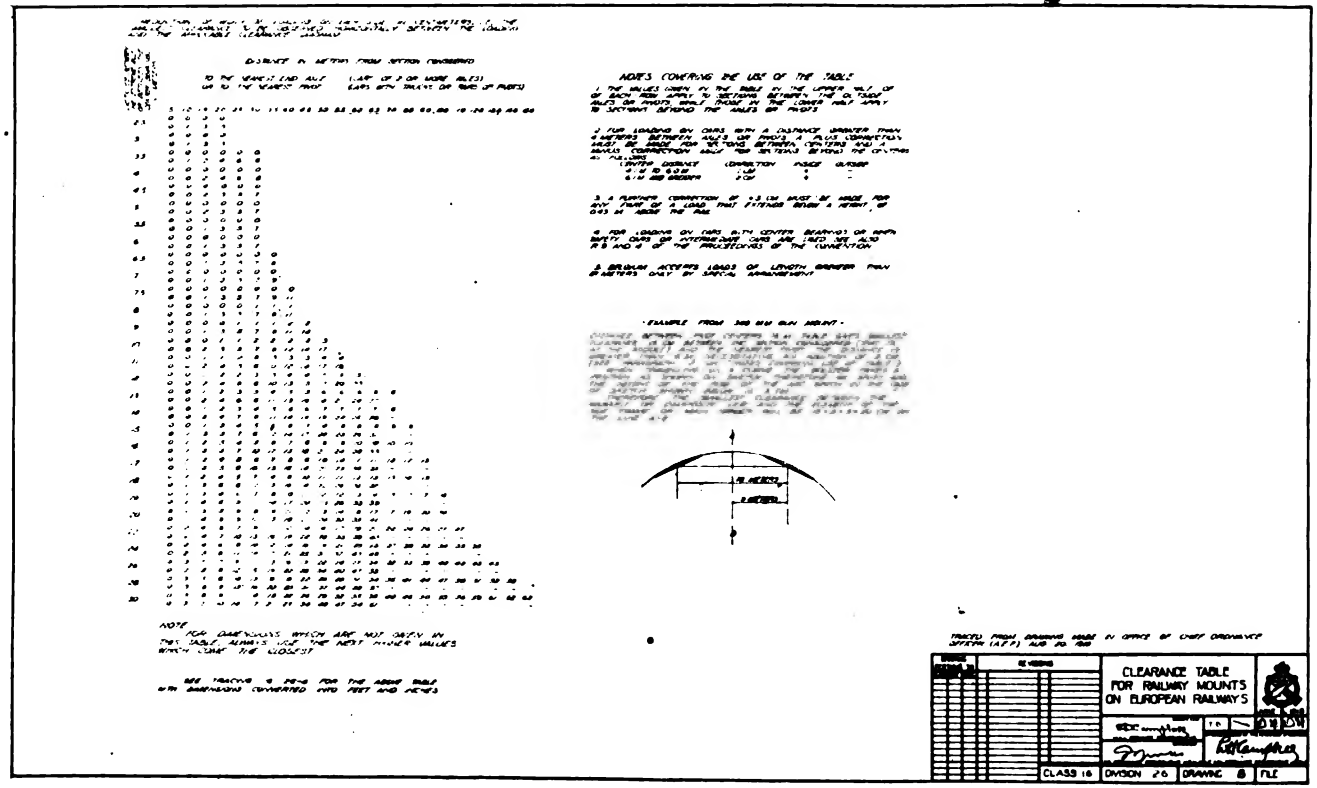

NOTES COVERING THE USE OF THE TABLE
· EXAMPLE FROM 360 MM GUN MOUNT ·
NOTE
TRACED FROM DRAWING MADE IN OFFICE OF CHIEF ORDNANCE OFFICER (A.E.F.)
CLEARANCE TABLE FOR RAILWAY MOUNTS ON EUROPEAN RAILWAYS
CLASS 16
DIVISION 26
DRAWING 8
FILE

PLATE 486

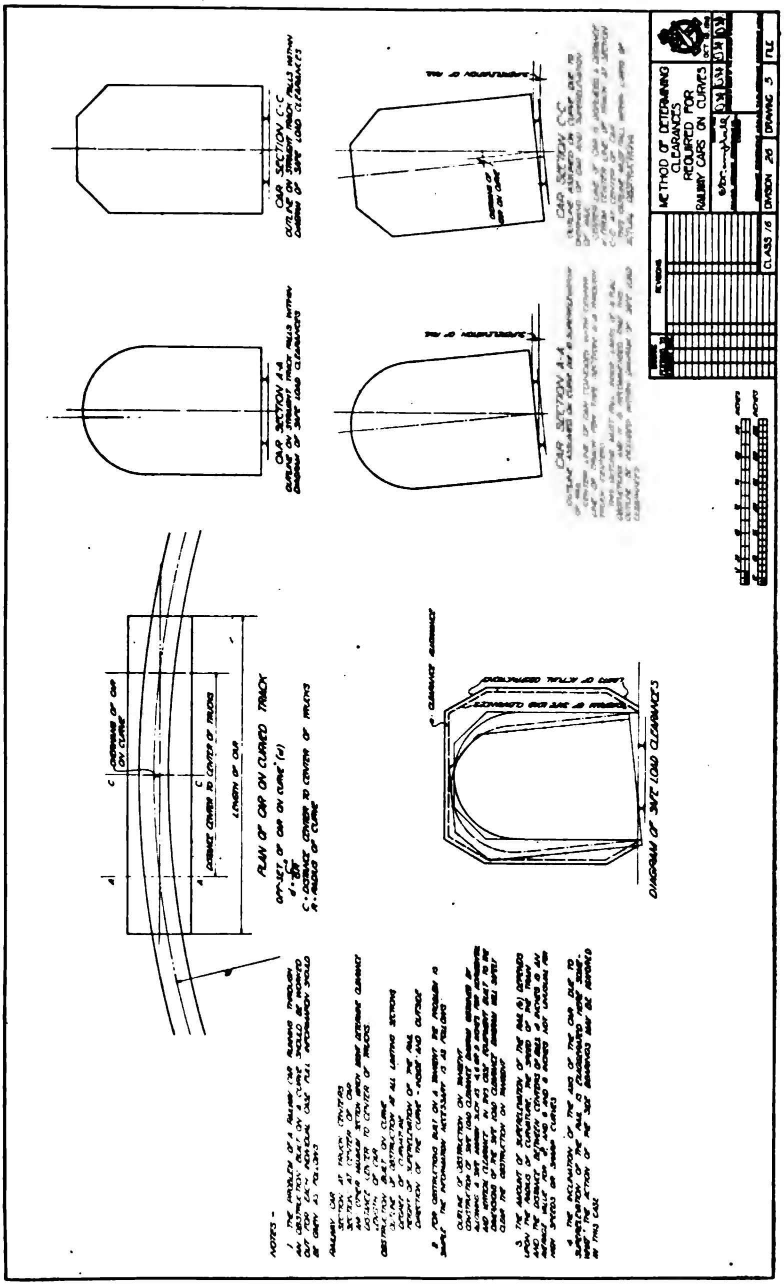
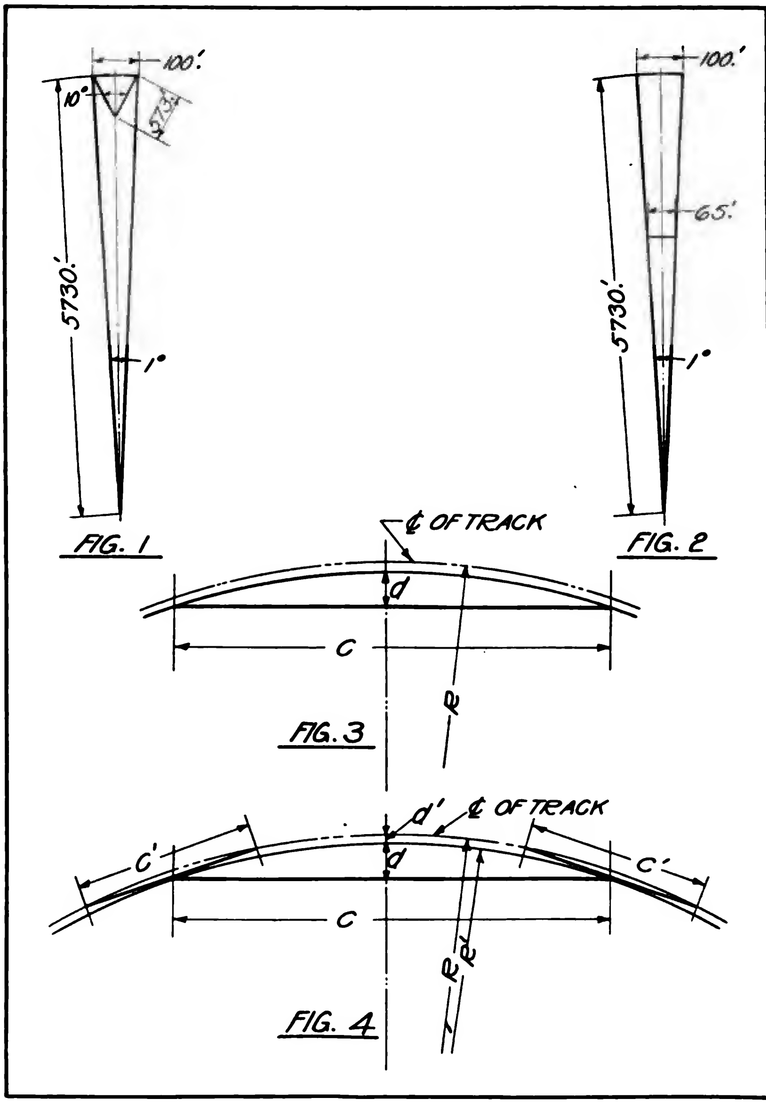

PLAN OF CAR ON CURVED TRACK
CAR SECTION A-A
CAR SECTION C-C
DIAGRAM OF SAFE LOAD CLEARANCES
METHOD OF DETERMINING
CLEARANCES
REQUIRED FOR
RAILWAY CARS ON CURVES
CLASS 16
DIVISION 26
DRAWING 5
FILE

PLATE 487



RAILWAY CURVES.

684. Spread of Rails.—In 1910, the A. R. M. M. Association recommended the widening of the gauge of track at curves as follows:

Curves 8 degrees and less should be standard gauge. Gauge should be widened ⅛ inch for each 2 degrees or fraction thereof over 8 degrees, to a maximum of 4 feet 9¼ inches for tracks of standard gauge. Gauge, including widening due to wear, should never exceed 4 feet 9½ inches.

685. Weight.—The weight of the railway mount is just as important as clearance in determining where and how it may be transported. Each type of mount, of course, weighs differently, and no attempt has been made in this clearance data to state what weights can be handled over the lines shown.

686. Inquiries were instituted as to what loads American railroads could handle when the clearance data was being obtained. The majority of railroads reported that they could handle loads of 180,000 pounds safely. On weights above this amount, most of the answers were either negative or ambiguous. The railroads, therefore, indicate that no general statement will be made as to what load they can handle. It was necessary to take up each type of mount with the roads in question giving full information as to wheel loads, wheel bases, total length of equipment with an outline or silhouette of the mount. The route contemplated was also given. Only by this procedure can a definite statement be secured from the railroads.

687. The axle loads for all railway mounts for use in France were fixed under the direction of Gen. Pershing. This was a limit of 17 metric tons per axle or approximately 37,500 pounds. The M. C. B. Association standard capacity for an axle with 6 by 11-inch journals is 50,000 pounds. So the wheel loads on all railway mounts were comparatively low. This decision required the extremely heavy mounts to have many wheels. The 12-inch, 50-caliber American gun sliding railway mount has 32 wheels. The 10-inch French Schneider sliding railway mount has two trucks of 12 wheels each. From the foregoing, it will be noted that while the total weight of some of the mounts (the American 12-inch gun sliding mount weighs 600,000 pounds), is exceedingly high, the loads per wheel are low.

688. Those dimensions with which the Service would be concerned in routing railway artillery over the United States are given with the various existing railway mounts on the following data and profile sheets. In each case the transverse section given within the United States composite clearance diagram is a composite of the obstructions throughout the length of the car that figure in the clearance. In the event that the clearance of any particular mount over certain roads is found so close as to be doubtful, it will be best to look up the drawings of that particular mount in the handbook to determine just where the limiting features on the mount are located.

689. Tables of Classified Information.—It was mentioned in the preface that at the request of the French and British Technical

Services, sections 3 and 10 were being divided and all descriptions and tabular data on French, British, and Italian mounts would be given in a second volume which would be available for official use only. The result is that less than one-third of the descriptive matter of section 3 and the tabular data of section 10 can be given in this volume. The American mounts on which data is given herein represent the highest points in the development of railway artillery so that an accurate conception of its present status can be gained. All of the data on the German mounts has been gained from study of captured handbooks and examination of the mounts themselves.

Table of classified data (42).

GUN.

No.	Caliber.	Model.	Total length. Dimensions.		Calibers.	Diameter over powder chamber.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
American:			*M.*	*In.*		*M.*	*In.*
1	4.7-inch howitzer	1913	2.8295	111.4	22.53	0.28448	11.2
2	7-inch	U. S. N., Mk. II	8.2042	323	36.6	.7366	29
3A	8-inch	1888, 1888 Mk. I and II	7.0739	278.5	32	.7612	29.97
B	do	U. S. N., Mk. II-1	6.4922	255.6	30	.781	30.75
C	do	U. S. N., Mk. III	7.7343	304.5	35	.781	30.75
D	do	U. S. N., Mk. III-3	8.7503	344.5	40	.781	30.75
E	do	U. S. N., Mk. V	8.7122	343	40	.781	30.75
F	do	1919, Mk. I and II	10.4706	412.23	42.64	.8382	33
4A	10-inch	1888, 1888 Mk. I and II	9.3281	367.25	34	.9779	38.5
B	do	U. S. N., Mk. I	8.3591	329.1	30	.9906	39
C	do	U. S. N., Mk. II	8.3591	329.1	30	.9906	39
D	do	U. S. N., Mk. I			34	.9906	39
5	12-inch mortar	1890, 1890 Mk. I	3.5844	141.12	10	.9652	38
6A	12-inch	1895	11.242	442.6	35	1.1303	44.5
B	do	U. S. N., Mk. I and II	11.2014	441	35	1.143	45
7	do	Beth. 1918	15.4432	608	50		
8	12-inch howitzer		6.6954	263.6	20	.8376	32.98
9	14-inch	1919	14.7637	581.25	40	1.1607	45.7
10	do	U. S. N., Mk. IV	18.1610	715	50	1.2192	48
11	do	do	18.1610	715	50	1.2192	48
12	do	do	18.1610	715	50	1.2192	48
13	do	do	18.1610	715	50	1.1607	48
14	16-inch howitzer	1918 Mk. I	7.8295	308.25	18	1.1165	43.96
15	do	do	7.8295	308.25	18	1.1165	43.96
16	16-inch	1919 M1	21.0007	826.8	50	1.5748	62
German:							
17	170-millimeter	1915	6.8	267.75	40	.216	.8505
18	210-millimeter	1913	9.45	372.09	45	.229	.9016
19	240-millimeter howitzer		7.2	283.5	30		
20	240-millimeter		9.5504	376	40		
21	280-millimeter	1904	11.2	441	40		
22	381-millimeter	1916	17.13	674.49	45	1	39.375

Table of classified data (42)—Continued.

GUN—Continued.

No.	Diameter of muzzle.		Total weight.		Maximum diameter powder chamber.		Length of powder chamber.		Capacity of powder chamber.	
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
American:	*M.*	*In.*	*Kg.*	*Lb.*	*M.*	*In.*	*M.*	*In.*	*M.*³	*In.*³
1	0.1778	7	953	2,100	0.12141	4.78	0.3632	14.3	0.0041	251
2	.2857	11.25	13,756	30,308	.24511	9.65	1.2994	51.159	.0596	3,639
3A	.3556	14	14,623	32,218	.2413	9.5	1.2954	51.	.0592	3,617
B	.3683	14.5			.2413	9.5	1.2875	50.69	.0562	3,431
C	.3175	12.5	13,344	29,400	.2413	9.5	1.2753	50.21	.0519	3,170
D	.3048	12	11,892	26,200	.2413	9.5	1.2753	50.21	.0519	3,170
E	.3556	14	18,402	40,544	.2413	9.5	1.5586	61.366	.0858	5,243
F	.3746	14.75	19,063	42,000	.2794	11	1.3931	54.85		
4A	.4267	16.8	30,502	67,200	.2997	11.8	1.6634	65.49	.0166	7,123
B										
C										
D										
5	.5334	21	13,217	29,120	.3175	12.5	.5367	21.13	.0438	2,674
6A	.5334	21	52,198	115,000	.3606	14.2	1.9692	77.53	.1992	12,166
B	.4826	19								
7			80,340	177,000	.3886	15.3	2.0657	81.33	.2393	14,611
8	.5275	20.77	18,420	40,582	.3403	13.4	.8469	33.345	.0784	4,790
9	.6096	24	65,728	144,808	.4267	16.8	2.2457	88.415	.3165	19,323
10	.5943	23.4	81,702	180,000	.4191	16.5	2.2457	88.415	.3203	19,555
11	.5943	23.4	81,702	180,000	.4191	16.5	2.2457	88.415	.3203	19,555
12	.5943	23.4	81,702	180,000	.4191	16.5	2.2457	88.415	.3203	19,555
13	.5943	23.4	81,702	180,000	.4191	16.5	2.2457	88.415	.3203	19,555
14	.7035	27.7	40,932	90,180	.4267	16.8	1.1607	45.698	.1686	10,298
15	.7035	27.7	40,932	90,180	.4267	16.8	1.1607	45.698	.1686	10,298
16	.6858	27	154,598	340,601	.5588	22	3.08008	121.263	.6552	40,000
German:										
17			10,500	23,131						
18			16,526	36,406						
19			18,908	41,654						
20			25,634	56,475						
21			45,300	99,796			1.9994	78.7106		
22			77,552	170,847	.425	16.78				

No.	Rifling.									Maximum powder pressure.	
	Grooves.					Width lands.		Twist.			
	Number.	Width.		Depth.				Angle.	Calibers per turn.	Kg./cm.²	Lb./in.²
	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)
American:		Mm.	In.	Mm.	In.	Mm.	In.				
1	42	5.3746	0.2116	1.016	0.04	3.556	0.14	4° 30′/8° 55′	40–20	2,038.9	29,000
2	42	7.4422 6.4262	.293 .253	1.27	.05	5.842 6.858	.23 .27	7° 10′	25	2,531.1	36,000
3A	48	9.4894	.3736	1.524	.06	3.81	.15	3° 30′/7° 10′	50–25	2,671.7	38,000
B	32	10.5333	.4147	1.27	.05	4.419	.174	7° 10′	25	2,249.8	32,000
C	32	12.3113	.4847	1.27	.05	4.419	.174	7° 10′	25	2,601.4	37,000
D	32	12.3113	.4847	1.27	.05	4.419	.174	7° 10′	25		
E										2,531.1	36,000
F	72	5.3111	.2091	1.524	.06	3.556	.14	3° 30′/7° 10′	50–25	2,671.7	38,000
4A	60	9.4894	.3736	1.524	.06	3.81	.15	3° 30′/7° 10′	50–25	2,671.7	38,000
B											
C											
D											
5	72	9.4894	.3736	1.524	.06	3.81	.15	4° 30′/8° 55′	40–20	2,601.4	37,000
6A	72	9.4894	.3736	1.524	.06	3.81	.15	3° 30′/7° 10′	50–25	2,671.7	38,000
B											
7	72								32	2,671.7	38,000
8	108	5.3111	.2091	1.524	.06	3.556	.14	4° 30′/8° 55′	40–20	2,601.4	37,000
9	126	5.3111	.2091	1.778	.07	3.556	.14	3° 30′/7° 10′	50–25	2,671.7	38,000
10										2,671.7	38,000
11										2,671.7	38,000
12										2,671.7	38,000
13										2,671.7	38,000
14	144	5.3111	.2091	3.048	.12	3.556	.14	4° 30′/8° 55′	40–20	2,671.7	38,000
15	144	5.3111	.2091	3.048	.12	3.556	.14	4° 30′/8° 55′	40–20	2,671.7	38,000
16	144	5.3111	.2091	3.048	.12	3.556	.14	3° 30′/7° 10′	50–25	2,671.7	38,000
German:											
17	52							5° 43′	31		
18	64							5° 43′	31		
19	52							5° 43′	31		
20	52							5° 43′	31		
21	80							5° 43′	31		
22	100	5.5626	.219			5.994	.236	5° 43′	31		

Table of classified data (42)—Continued.

GUN—Continued.

No.	Muzzle velocity.		Muzzle energy (max.).		Velocity of rotation at muzzle (max.), r. p. m.	Life in full rounds.	Maximum range.		
							Range.		Elevation.
	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)
American:	*M./s.*	*Ft./s.*	*M./T.*	*Ft./T.*			*Km.*	*Yds.*	
1	396	1,300	73.13	704	9,958		9.14	10,000	40 degrees.
2	822	'2,700	867.27	8,343	10,697		15 53	17,000	15 degrees 10 minutes.
3A	594/792	1,950/2,600	973.65	9,372	7,918	910	19.19	21,000	42 degrees.
B	670	2,200	697.10	6,710	7,920				Do.
C	701	2,300	761.92	7,334	8,280				Do.
D	701	2,300	761.92	7,334	8,280				Do.
E	853	2,800	1,129.28	10,870					Do.
F	1,021	3,350	1,618.39	15,578	1,005	550	29.2	31,944	45 degrees.
4A	685	2,250	2,249.42	21,652	6,480	640	24.58	26,900	Do.
B									Do.
C									Do.
D									Do.
5	457	1,500	1,136.03	10,935	4,500	1,150	13.98	15,300	Do.
6A	792	2,600	3,407.79	32,802	5,400	370	26.50	29,000	38 degrees.
B									Do.
7	975	3,200	5,168.52	49,750		240	41.13	45,000	40 degrees.
8	594	1,950	1,919.26	18,474	5,850		19.74	21,600	45 degrees.
9	883	2,900	7,272.3	70,000	4,834		29.25	32,000	30 degrees.
10	853	2,800	7,920.51	76,240		220	*36.56	40,000	38 degrees.
11	853	2,800	7,920.51	76,240		220	36.56	40,000	43 degrees.
12	853	2,800	7,920.51	76,240		220	36.56	40,000	40 degrees.
13	853	2,800	7,920.51	76,240		220	36.56	40,000	38 degrees.
14	579	1,900	4,315.59	41,540	4,275	380	21.23	23,000	45 degrees.
15	579	1,900	4,315.59	41,540	4,275	380	21.23	23,000	Do.
16	822	2,700	*12,615.36	121,430	1,620				
German:									
17							24	26,256	47.5 degrees.
18							26.4	28,881	45 degrees.
19							18.7	20,457	Do.
20									Do.
21							31	33,914	Do.
22							47.48	51,948	47.5 degrees.

MOUNT.

No.	Type.	Model.	Make.	Characteristics.					
				Extent of traverse.	Firing angle.		Recoil.		
					Maximum.	Minimum.	Type.	Length.	
	(39)	(40)	(41)	(42)	(43)	(44)	(45)	(46)	(47)
American:				*Degrees.*	*D. Min.*			*M.*	*In.*
1	Outrigger	1917	U. S. Ordnance	360	40	0	Cradle	0.345	12
2	do	1918	do	360	15 10	0	do	.533	21
3A	do	1918 MI	do	360	42	0	do	1.219	48
B	do	do	do	360	42	0	do	1.219	48
C	do	do	do	360	42	0	do	1.219	48
D	do	do	do	360	42	0	do	1.219	48
E	do	do	do	360	42	0	do	1.219	48
F	do	do	do	360	42	0	do	1.219	48
4A	Sliding	1919	Schneider	0	45	0	Sliding	*1	39.3
B	do	do	do	0	45	0	do	*1	39.3
C	do	do	do	0	45	0	do	*1	39.3
D	do	do	do	0	45	0	do	*1	39.3
5	Outrigger	1918 MII	U. S. Ordnance	360	65	20	Cradle	.762	30
6A	Ground platform	1918	Batignolles	10	38	15	do	.9	35.4
B	do	do	do	10	38	15	do	.9	35.4
7	Sliding	do	U. S. Ordnance	0	40	15	Sliding	*1	39.3
8	Outrigger	do	do	360	60	20	Cradle	.914	36
9	Sliding—ground platform	E	do	[j] 5–360	30	0	do	1.52	60
10	Ground platform	Mk. I	U. S. Navy	10	45	15	do	1.142	45
11	Rolling	Mk. II	do	0	43	0	Rolling	1.01	*40
12	Sliding	1918	U. S. Ordnance	[j] 5	38		Sliding	*1	39.3
13	do	1919	do	[j] 5	38		do	*1	39.3
14	Rolling—ground platform	1918	do	10	65	20	Cradle	1.219	48
15	Ground platform	E	do	360	65	20	do	1.219	48
16	Rolling	E	do	0	40		Cradle—rolling	1.219	48
German:									
17	Ground platform •	170-millimeter, 1915	Krupp	[j] 36–360	47 30	20	Cradle	.381	15
18	do	210-millimeter	do	[j] 25–360	45	20	do	.61	24.01
19	Ground platform	240-millimeter	do	[j] 4–360	45	20	do	.508	20.02
20	do	do	do	360	45	20	do	.596	23.5
21	do	280-millimeter	do	[j] 2–360	45	20	do	.762	30
22	do	380-millimeter, 1918	do	[j] 2–360	55	20	do	1.25	49.21

Table of classified data (42)—Continued.

MOUNT—Continued.

No.	Characteristics.		Dimensions.					
	Loading system.	Rate of fire per hour.	Length over buffers.		Center to center of truck bolsters.		Height of trunnions above track.	
	(48)	(49)	(50)	(51)	(52)	(53)	(54)	(55)
American:			*M.*	*Feet.*	*M.*	*Feet.*	*M.*	*Feet.*
1	Hand tray	60	9.75	29.79	6.24	20.5		
2	Crane and tray	50	14.103	46.27	9.29	30.5	2.26	7.43
3A	do	45	14.103	46.27	9.29	30.5	3.30	9.84
B	do	45	14.103	46.27	9.29	30.5	3.30	9.84
C	do	45	14.103	46.27	9.29	30.5	3.30	9.84
D	do	45	14.103	46.27	9.29	30.5	3.30	9.84
E	do	45	14.103	46.27	9.29	30.5	3.30	9.84
F	do	45	14.103	46.27	9.29	30.5	3.30	9.84
4A	Trolley and tray	20	27.2003	89.24	17.29	56.75	3.55	11.66
B	do	20	27.2003	89.24	17.29	56.75	3.55	11.66
C	do	20	27.2003	89.24	17.29	56.75	3.55	11.66
D	do	20	27.2003	89.24	17.29	56.75	3.55	11.66
5	Crane and tray	25	14.103	46.270	9.29	30.5	2.91	9.56
6A	do	20	19.967	65.51	12.98	42.58	3.24	10.62
B	do	20	19.967	65.51	12.98	42.58	3.24	10.62
7	Crane and shot truck	20	30.611	100.43	19.40	63.66	3.60	11.83
8	Crane and tray	25	12.85	42.16	8.53	28	2.88	9.45
9	Trolley shot truck	30	21.96	72.08	15.59	51.16	3.08	10.12
10	do	30	25.804	84.66	16.45	54	2.74	8.98
11	Trolley and tray	15	27.67	90.81	15.84	52	3.24	10.66
12	Crane and shot truck	20	34.68	113.8	18.84	61.83	3.49	11.48
13	do	20	32.84	107.77	18.38	60.33	3.49	11.46
14	Crane and tray	20	17.77	58.33	10.97	36	3.26	*10.7
15	Trolley shot truck	20	15.18	49.83	10.15	33.33	1.77	5.81
16	Crane shot truck	12	36.75	120.58	22.50	73.83	2.84	9.33
German:								
17	Hand tray	60	16.75	54.94	13.53	44.37		
18	Trolley tray	40	15.85	51.98	11.89	38.99	2.75	9.02
19	do	30	15.85	51.98	11.89	38.99	3.07	10.06
20	do	30	19.68	64.58				
21	Trolley shot truck	30	21.61	70.91	14	45.92	3.4	11.15
22	Windlass shot truck	20	31.61	103.68	21.15	69.37	3.07	10.0

No.	Dimensions.				Weights.					
	Maximum width.		Center to center of axles.		Recoiling parts.		Top carriage complete without gun.		Car body.	
	(56)	(57)	(58)	(59)	(60)	(61)	(62)	(63)	(64)	(65)
American:	*Meters.*	*Feet.*	*Meters.*	*Feet.*	*Kilograms.*	*Pounds.*	*Kilograms.*	*Pounds.*	*Kilograms.*	*Pounds.*
1			1.47	4.83						
2	2.89	9.5	1.77	5.83			30,089	66,292	24,238	53,400
3A	2.89	9.5	1.77	5.83	16,421	36,178	26,402	58,300	27,687	61,000
B	2.89	9.5	1.77	5.85	16,421	36,178	26,402	58,300	27,687	61,000
C	2.89	9.5	1.77	5.83	16,421	36,178	26,402	58,300	27,687	61,000
D	2.89	9.5	1.77	5.83	16,421	36,178	26,402	58,300	27,687	61,000
E	2.89	9.5	1.77	5.83	16,421	36,178	26,402	58,300	27,687	61,000
F	2.89	9.5	1.77	5.83	16,421	36,178	26,402	58,300	27,687	61,000
4A	3.05	10.01	1.17	n3.85	183,121	403,440	None.	None.	105,913	233,340
B	3.05	10.01	1.17	n3.85	183,121	403,440	None.	None.	105,913	233,340
C	3.05	10.01	1.17	3.85	183,121	403,440	None.	None.	105,913	233,340
D	3.05	10.01	1.17	3.85	183,121	403,440	None.	None.	105,913	233,340
5	2.89	9.5	.99	3.25	18,941	41,730	26,271	57,880	27,234	60,000
6A	2.94	9.66	*1.4	*4.59	56,114	123,628	34,210	75,370	28,573	61,814
B	2.94	9.66	*1.4	*4.59	56,114	123,628	34,210	75,370	28,573	61,814
7	2.63	8.66	1.06	3.5	249,645	550,000	None.	None.	123,006	271,000
8	2.99	9.83	1.01	3.33	22,326	49,188	28,306	62,363	46,697	102,880
9	3.20	10.5	1.21	4.0	68,375	150,640	None.	None.	68,184	150,220
10	2.87	9.41	1.37	4.5	37,673	*83,000	None.	None.		
11	2.94	9.66	1.03	3.41	276,879	610,000	None.	None.		
12	2.81	9.25	1.04	3.44	315,000	693,945	None.	None.	96,000	211,488
13	2.69	8.84	1.03	3.41	329,400	724,850	None.	None.	100,000	220,300
14	2.94	9.66	.91	3.0	43,165	95,100	None.	None.		
15	3.09	10.16	1.44	4.75	43,165	95,100	None.	None.		
16	3.04	10	1.21	4.0	385,815	850,000	None.	None.	98,950	*218,000
German:										
17							None.	None.		
18							None.	None.		
19	3.4	11.15					None.	None.		
20							None.	None.		
21							None.	None.		
22			1.36	4.46			None.	None.		

Table of classified data (42)—Continued.

MOUNT—Continued.

No.	Weights.						Trucks.				
	Span bolster.		Axle load, maximum.		Total weight.		Number.	Number axles per truck.			
								Front.	Rear.	Exterior.	Interior.
	(66)	(67)	(68)	(69)	(70)	(71)	(72)	(73)	(74)	(75)	(76)
American:	*Kilograms.*	*Pounds.*	*Kilograms.*	*Pounds.*	*Kilograms.*	*Pounds.*					
1	None.	None.	5,147	11,374	20,660	45,495	2	2	2		
2	None.	None.	19,404	42,750	77,616	171,000	2	2	2		
3A	None.	None.	19,903	43,850	78,978	174,000	2	2	2		
B	None.	None.	19,903	43,850	78,978	174,000	2	2	2		
C	None.	None.	19,903	43,850	78,978	174,000	2	2	2		
D	None.	None.	19,903	43,850	78,978	174,000	2	2	2		
E	None.	None.	19,903	43,850	78,978	174,000	2	2	2		
F	None.	None.	19,903	43,850	78,978	174,000	2	2	2		
4A	None.	None.	15,508	34,167	183,121	403,440	2	6	6		
B	None.	None.	15,508	34,167	183,121	403,440	2	6	6		
C	None.	None.	15,508	34,167	183,121	403,440	2	6	6		
D	None.	None.	15,508	34,167	183,121	403,440	2	6	6		
5	None.	None.	14,131	31,133	80,340	177,000	2	3	3		
6A	None.	None.	18,530	40,825	146,175	322,044	2	4	4		
B	None.	None.	18,530	40,825	146,175	322,044	2	4	4		
7			16,654	36,692	249,645	550,000	4			4	4
8	None.	None.	16,309	35,931	88,620	195,243	2	3	3		
9	None.	None.	24,987	55,051	198,218	436,700	2	4	4		
10			24,056	53,000	244,000	537,532	4			3	3
11			15,977	35,200	276,879	610,000	4			5	5
12	45,000	99,135	15,430	33,992	308,600	679,845	4			5	5
13	38,700	85,256	16,900	37,230	329,400	724,850	4			5	5
14	None.	None.	12,965	28,565	141,957	312,750	2	6	6		
15	None.	None.	18,534	40,833	111,205	245,000	2	3	3		
16	22,695	*50,000	16,068	35,400	385,815	850,000	4			6	6
German:											
17	None.	None.	15,011	33,069	60,045	132,279	2	2	2		
18	None.	None.	11,804	26,004	94,440	208,051	2	4	4		
19	None.	None.	14,137	31,143	113,100	249,159	2	4	4		
20	None.	None.	*14,500	31,943	103,303	227,590	2	4	4		
21	None.	None.	*14,500	31,943	150,027	330,530	2	5	5		
22					267,900	595,050	4	5 each.	4 each.		

TRUCKS.

No.	Journals.		Wheels.			Total weight of each truck.							
			Type.	Diameter.		Front.		Rear.		Exterior.		Interior.	
	(77)	(78)	(79)	(80)	(81)	(82)	(83)	(84)	(85)	(86)	(87)	(88)	(89)
American:	M.	In.		M.	In.	Kg.	Lb.	Kg.	Lb.	Kg.	Lb.	Kg.	Lb.
1	0.101 by 0.178	4 by 7		0.66	26								
2	.152 by .279	6 by 11	Cast steel	.838	33	4,765	10,500	4,765	10,500				
3A	.152 by .279	6 by 11	do	.838	33	4,765	10,500	4,765	10,500				
B	.152 by .279	6 by 11	do	.838	33	4,765	10,500	4,765	10,500				
C	.152 by .279	6 by 11	do	.838	33	4,765	10,500	4,765	10,500				
D	.152 by .279	6 by 11	do	.838	33	4,765	10,500	4,765	10,500				
E	.152 by .279	6 by 11	do	.838	33	4,765	10,500	4,765	10,500				
F	.152 by .279	6 by 11	do	.838	33	4,765	10,500	4,765	10,500				
4A	.139 by .254	5.5 by 10	do	.838	33	23,353	51,450	23,353	51,450				
B	.139 by .254	5.5 by 10	do	.838	33	23,353	51,450	23,353	51,450				
C	.139 by .254	5.5 by 10	do	.838	33	23,353	51,450	23,353	51,450				
D	.139 by .254	5.5 by 10	do	.838	33	23,353	51,450	23,353	51,450				
5	.139 by .254	5.5 by 10	do	.711	28	6,808	15,000	6,808	15,000				
6A	.169 by .309	6.69 by 12.2	do	.919	36.22	14,751	32,500	14,751	32,500				
B	.139 by .254	5.5 by 10	do	.762	30								
7	.139 by .254	5.5 by 10	do	.711	28	6,808	15,000	6,808	15,000				
8	.165 by .304	6.5 by 12	do	.711	28								
9	.152 by .279	6 by 11	do	.787	31	12,709	28,000	12,709	28,000				
10	.228 by .304	9 by 12	Locomotive	.914	36								
11	.165 by .304	6.5 by 12	do	.762	30								
12	.165 by .304	6.5 by 12	do	.838	33					16,340	36,000	10,893	24,000
13	.165 by .304	6.5 by 12	do	.711	28					16,930	37,300	12,119	26,700
14	.165 by .304	6.5 by 12	do	.711	28	17,475	38,500	17,475	38,500				
15	.152 by .279	6 by 11	Cast steel	.711	28								
16	.165 by .304	6.5 by 12	do	.838	33					18,156	40,000	18,156	40,000
German:													
17			Cast-steel spokes	.838	* 33								
18			Cast steel										
19			do										
20			do										
21			do										
22	.140 by .320	5.5 by 12.6	do	.95	37.4								

Table of classified data (42)—Continued.

ANCHORAGE.

No.	Type.	Total number components.	Total weight.		Platform car.			Time to install.	Time to remove.
					Type.	Weight.			
	(90)	(91)	(92)	(93)	(94)	(95)	(96)	(97)	(98)
American:			Kg.	Lb.		Kg.	Lb.		
1	Outrigger	4			None			45 minutes	25 minutes.
2	do	10			do			do	Do.
3A	do	18			do			do	Do.
B	do	18			do			do	Do.
C	do	18			do			do	Do.
D	do	18			do			do	Do.
E	do	18			do			do	Do.
F	do	18			do			3 hours [a]	1 hour.[a]
4A	Sliding	30	12,083	26,620	Com. flat	[*] 12,981	28,600	do. [a]	Do. [a]
B	do	30	12,083	26,620	do	12,981	28,600	do. [a]	Do. [a]
C	do	30	12,083	26,620	do	12,981	28,600	do. [a]	Do. [a]
D	do	30	12,083	26,620	do	12,981	28,600	45 minutes	25 minutes.
5	Outrigger	18			None			3 hours [a]	1 hour.[a]
6A	Ground platform	6	15,680	34,550	Special	20,420	45,000	do. [a]	Do. [a]
B	do	6	15,680	34,550	do	20,420	45,000	do. [a]	Do. [a]
7	Sliding	48	67,750	149,419	Com. flat	12,981	28,600	45 minutes	25 minutes.
8	Outrigger	18			None			3 hours	2 hours.
9	Sliding-ground platform	1	30,867	68,000	Steel flat	19,971	44,000	3 to 5 days	12 hours.[*]
10	Ground platform	[*] 10			Com. flat	12,981	28,600	5 days	Not removed.
11	Rolling	0			None			3 hours [a]	1 hour.[a]
12	Sliding	48			Com. flat	12,981	28,600	do. [a]	Do. [a]
13	do	48			do	12,981	28,600	3 to 5 days	12 hours.
14	Rolling-ground platform	[b] 10			do	12,981	28,600	2 days [*]	Do.
15	Ground platform	8			do	19,971	44,000	5 days	Not removed.
16	Epi.				None				
German:									
17	Track,[d] ground platform	10			Com. flat	12,981	[*] 28,600	15 minutes [e] 12 hours [f]	10 minutes.[e] 3 hours.[f]
18	do.[d]	[g] 4 [h] 86			do	12,981	[*] 28,600	7 days [g] 5 days [h]	Not removed. 2 days.
19	do.[d]	[g] 4 [h] 86			do	12,981	[*] 28,600	7 days [g] 5 days [h]	Not removed. 2 days.
20	do.[d]				do			3 to 5 weeks	2 weeks.
21	do.[d]	[g] 4 [h] 86			do			7 days [g] 5 days [h]	Not removed. 2 days.
22	do.[d]				do			3 to 7 weeks	3 weeks.

AMMUNITION—CAR.

No.	Length over buffers.		Center to center trucks.		Maximum height above rail.		Capacity (105)	Total weight.			
								Loaded.		Empty.	
	(99)	(100)	(101)	(102)	(103)	(104)		(106)	(107)	(108)	(109)
American:	*Meters.*	*Feet.*	*Meters.*	*Feet.*	*Meters.*	*Feet.*	*Rounds.*	*Kilograms.*	*Pounds.*	*Kilograms.*	*Pounds.*
1	12.14	39.83	7.99	26.23	3.64	11.96				15,205	33,500
2	12.14	39.83	7.99	26.23	3.64	11.96	96	25,005	55,090	15,205	33,500
3A	12.14	39.83	7.99	26.23	3.64	11.96	96	32,869	72,416	15,205	33,500
B	12.14	39.83	7.99	26.23	3.64	11.96	96	32,869	72,416	15,205	33,500
C	12.14	39.83	7.99	26.23	3.64	11.96	96	32,869	72,416	15,205	33,500
D	12.14	39.83	7.99	26.23	3.64	11.96	96	32,869	72,416	15,205	33,500
E	12.14	39.83	7.99	26.23	3.64	11.96	96	32,869	72,416	15,205	33,500
F	12.14	39.83	7.99	26.23	3.64	11.96	96	32,869	72,416	15,205	33,500
4A	12.14	39.83	7.99	26.23	3.64	11.96	48	29,809	65,674	15,205	33,500
B	12.14	39.83	7.99	26.23	3.64	11.96	48	29,809	65,674	15,205	33,500
C	12.14	39.83	7.99	26.23	3.64	11.96	48	29,809	65,674	15,205	33,500
D	12.14	39.83	7.99	26.23	3.64	11.96	48	29,809	65,674	15,205	33,500
5	12.14	39.83	7.99	26.23	3.64	11.96	48	39,380	86,760	15,205	33,500
6A	12.14	39.83	7.99	26.23	3.64	11.96	36	37,098	81,732	15,205	33,500
B	12.14	39.83	7.99	26.23	3.64	11.96	36	37,098	81,732	15,205	33,500
7	12.14	39.83	7.99	26.23	3.64	11.96	36	32,150	70,832	15,205	33,500
8	12.14	39.83	7.99	26.23	3.64	11.96	48	32,526	71,660	15,205	33,500
9	12.14	39.83	7.99	26.23	3.64	11.96	24	39,171	86,300	15,205	33,500
10	12.14	39.83	7.99	26.23	3.64	11.96	25	36,425	80,250	15,205	33,500
11	12.14	39.83	7.99	26.23	3.64	11.96	25	36,425	80,250	15,205	33,500
12	12.14	39.83	7.99	26.23	3.64	11.96	25	36,425	80,250	15,205	33,500
13	12.14	39.83	7.99	26.23	3.64	11.96	25	36,425	80,250	15,205	33,500
14	12 14	39.83	7.99	26.23	3.64	11.96	20	41,531	91,500	15,205	33,500
15	12 14	39.83	7.99	26.23	3.64	11.96	20	41,531	91,500	15,205	33,500
16	12.14	39.83	7.99	26.23	3.64	11.96	20	44,709	98,500	15,205	33,500
German:											
17											
18											
19											
20											
21											
22											

Table of classified data (42)—Continued.

AMMUNITION—POWDER.

No.	Weight of full charge.		Weights of reduced charges.									
			A		B		C		D		E	
	(110)	(111)	(112)	(113)	(114)	(115)	(116)	(117)	(118)	(119)	(120)	(121)
	Kilograms.	*Pounds.*	*Kilograms.*	*Pounds.*	*Kilograms.*	*Pounds.*	*Kilograms.*	*Pounds.*	*Kilograms.*	*Pounds.*	*Kilograms.*	*Pounds.*
American:												
1	27.2	60										
2	27.2	[k]60	26.32	[m] 58								
3A	37.3	[m] 82.375	32.04	[k] 70.628	22.86	[k]50.375						
B	37.3	[m] 82.375	32.04	[k] 70.628	22.86	[k] 50.375						
C	37.3	[m] 82.375	32.04	[k] 70.628	22.86	[k] 50.375						
D	37.3	[m] 82.375	32.04	[k] 70.628	22.86	[k] 50.375						
E	37.3	[m] 82.375	32.04	[k] 70.628	22.86	[k] 50.375						
F	37.3	[m] 82.375	32.04	[k] 70.628	22.86	[k] 50.375						
4A	72.76	[k] 160.312	70.35	[m] 155	55.	[k] 121.187						
B	72.76	[k] 160.312	70.35	[m] 155	55.	[k] 121.187						
C	72.76	[k] 160.312	70.35	[m] 155	55.	[k] 121.187						
D	72.76	[k] 160.312	70.35	[m] 155	55.	[k] 121.187						
5	28.9	63.59	19.29	42.5	14.58	32.125	11.26	24.812	8.96	19.75	7.63	16.812
6A	122.46	[m] 269.81	103.48	[k] 228.125	71.48	157.5						
B	122.46	[m] 269.81	103.48	[k] 228.125								
7	152.96	337	108.93	240								
8	43.12	95										
9	245.1	[m] 540	238.29	525	190.63	[k] 420	177.02	[m] 390				
10	213.33	470	159.99	352.5	61.27	135						
11	213.33	470	159.99	352.5	61.27	135						
12	213.33	470	159.99	352.5	61.27	135						
13	213.33	470	159.99	352.5	61.27	135						
14	108.93	240	78.07	172	59	130	48.79	107.5	42.43	93.5		
15	108.93	240	78.07	172	59	130	48.79	107.5	42.43	93.5		
16	385.81	850										
German:												
17	83.908	184.84										
18	143.088	315.22										
19	29.11	64.15										
20	45.33	99.87										
21	69.7	153.58										
22	183.12	403.45										

AMMUNITION—PROJECTILES: A.

No.	Type.	Target.	Weight. Total.		Weight. Explosive.		Length base to point.	
	(122)	(123)	(124)	(125)	(126)	(127)	(128)	(129)
			Kg.	Lb.	Kg.	Lb.	M.	In.
American:								
1	A. P.	Naval	27.23	60	1.47	3.24	0.4704	18.52
2	do.	do.	74.80	165	1.81	4		
3A	Long point shot	do.	101.21	323	2.45	5.4		
B	do.	do.	101.21	323	2.45	5.4		
C	do.	do.	101.21	323	2.45	5.4		
D	do.	do.	101.21	323	2.45	5.4		
E	do.	do.	101.21	323	2.45	5.4		
F	do.	do.	101.21	323	2.45	5.4		
4A	H. E.	Land	231.48	510	25.55	56.3		
B	do.	do.	231.48	510	25.55	56.3		
C	do.	do.	231.48	510	25.55	56.3		
D	do.	do.	231.48	510	25.55	56.3		
5	Short cap shell	Naval	474.77	1,046	26.5	58.4		
6A	Long point shot	do.	485.67	1,070	8.8	19.4		
B	do.	do.	485.67	1,070	8.8	19.4		
7	H. E.	Land	317.73	700	42.66	90.4	1.1417	44.95
8	do.	do.	317.73	700	42.66	90.4	1.1417	44.95
9	A. P. shell	Naval	753.47	1,660	38.58	85	1.593	62.72
10	do.	do.	635.46	1,400	40.39	89	1.1417	44.95
11	do.	do.	635.46	1,400	40.39	89	1.1417	44.95
12	do.	do.	635.46	1,400	40.39	89	1.1417	44.95
13	do.	do.	635.46	1,400	40.39	89	1.1417	44.95
14	H. E.	Land	753.47	1,660	102.76	226.4	1.5958	62.83
15	do.	do.	753.47	1,660	102.76	226.4	1.5958	62.83
16	A. P. shell	Naval	862.41	2,400	57.4	126.55	1.8161	71.50
German:								
17	H. E.	Land	63.99	141	3.34	7.37	.799	31.46
18	do.	do.	108.02	238	6.85	15.1	1.629	64.1418
19	do.	do.	151.14	333	15.61	34.4	.984	38.74
20	do.	do.	151.14	333	15.61	34.4	.984	38.74
21	do.	do.	240.11	529	15.88	35	.812	31.97
22	do.	do.	743.48	1,638	66.04	145.5	2.05	80.71

Table of classified data (42)—Continued.

AMMUNITION—PROJECTILES: B.

No.	Type. (130)	Target. (131)	Weight. Total. (132)	Weight. Total. (133)	Weight. Explosive. (134)	Weight. Explosive. (135)	Length base to point. (136)	Length base to point. (137)
			Kg.	*Lb.*	*Kg.*	*Lb.*	*M*	*In.*
American:								
1	Shrapnel	Land	27.23	60	4.28	9.44	.4323	17.02
2	H. E	do	69.44	153	10.89	24		
3A	Long point shell	Naval	14.66	323	7.12	15.7		
B	do	do	14.66	323	7.12	15.7		
C	do	do	14.66	322	7.12	15.7		
D	do	do	14.66	323	7.12	15.7		
E	do	do	14.66	323	7.12	15.7		
F	do	do	14.66	323	7.12	15.7		
4A	A. P. shot	do	280.05	617	5.49	12.1		
B	do	do	280.05	617	5.49	12.1		
C	do	do	280.05	617	5.49	12.1		
D	do	do	280.05	617	5.49	12.1		
5	Short cap shell	do	374.01	824	14.84	32.7		
6A	Long point shell	do	485.67	1,070	26.55	58.51		
B	do	do	485.67	1,070	26.55	58.51		
7								
8								
9	H. E. shell	Land	544.68	1,200	69.90	154	1.5506	61.05
10	do	do	544.68	1,200	69.90	154	1.5506	61.05
11	do	do	544.68	1,200	69.90	154	1.5506	61.05
12	do	do	544.68	1,200	69.90	154	1.5506	61.05
13	do	do	544.68	1,200	69.90	154	1.5506	61.05
14								
15								
16								
German:								
17								
18								
19								
20								
21								
22								

No.	Type.	Target.	Weight.				Length, base to point.	
			Total.		Explosive.			
	(138)	(139)	(140)	(141)	(142)	(143)	(144)	(145)
			Kg.	Lb.	Kg.	Lb.	M.	In.
American:								
1								
2								
3 A	H. E. shell	Land	90.78	200	13.43	29.6	0.6898	27.16
B	do	do	90.78	200	13.43	29.6	.6898	27.16
C	do	do	90.78	200	13.43	29.6	.6898	27.16
D	do	do	90.78	200	13.43	29.6	.6898	27.16
E	do	do	90.78	200	13.43	29.6	.6898	27.16
F	do	do	90.78	200	13.43	29.6	.6898	27.16
4 A	Shell	Naval	280.05	617	15.25	33.6		
B								
C								
D								
5	H. E.	Land	317.73	700	42.8	94.3		
6 A	Shell	Naval	408.51	900	20.24	44.6		
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
German:								
17								
18								
19								
20								
21								
22								

Table of classified data (42)—Continued.

AMMUNITION—PROJECTILES: B.

No.	Type.	Target.	Weight. Total.		Weight. Explosive.		Length base to point.	
	(130)	(131)	(132)	(133)	(134)	(135)	(136)	(137)
American:			*Kg.*	*Lb.*	*Kg.*	*Lb.*	*M.*	*In.*
1	Shrapnel	Land	27.23	60	4.28	9.44	.4323	17.02
2	H. E.	do	69.44	153	10.89	24		
3A	Long point shell	Naval	14.66	323	7.12	15.7		
B	do	do	14.66	323	7.12	15.7		
C	do	do	14.66	322	7.12	15.7		
D	do	do	14.66	323	7.12	15.7		
E	do	do	14.66	323	7.12	15.7		
F	do	do	14.66	323	7.12	15.7		
4A	A. P. shot	do	280.05	617	5.49	12.1		
B	do	do	280.05	617	5.49	12.1		
C	do	do	280.05	617	5.49	12.1		
D	do	do	280.05	617	5.49	12.1		
5	Short cap shell	do	374.01	824	11.84	32.7		
6A	Long point shell	do	485.67	1,070	26.55	58.51		
B	do	do	485.67	1,070	26.55	58.51		
7								
8								
9	H. E. shell	Land	544.68	1,200	69.90	154	1.5506	61.05
10	do	do	544.68	1,200	69.90	154	1.5506	61.05
11	do	do	544.68	1,200	69.90	154	1.5506	61.05
12	do	do	544.68	1,200	69.90	154	1.5506	61.05
13	do	do	544.68	1,200	69.90	154	1.5506	61.05
14								
15								
16								
German:								
17								
18								
19								
20								
21								
22								

AMMUNITION—PROJECTILES: C.

No.	Type.	Target.	Weight.				Length, base to point.	
			Total.		Explosive.			
	(138)	(139)	(140)	(141)	(142)	(143)	(144)	(145)
American:			*Kg.*	*Lb.*	*Kg.*	*Lb.*	*M.*	*In.*
1								
2								
3 A	H. E. shell	Land	90.78	200	13.43	29.6	0.6898	27.16
B	do	do	90.78	200	13.43	29.6	.6898	27.16
C	do	do	90.78	200	13.43	29.6	.6898	27.16
D	do	do	90.78	200	13.43	29.6	.6898	27.16
E	do	do	90.78	200	13.43	29.6	.6898	27.16
F	do	do	90.78	200	13.43	29.6	.6898	27.16
4 A	Shell	Naval	280.05	617	15.25	33.6		
B								
C								
D								
5	H. E.	Land	317.73	700	42.8	94.3		
A	Shell	Naval	408.51	900	20.24	44.6		

Table of classified data (42)—Continued.

AMMUNITION—PROJECTILES: D.

No.	Type.	Target.	Weight.				Length, point to base.	
			Total.		Explosive.			
	(146)	(147)	(148)	(149)	(150)	(151)	(152)	(153)
			Kg.	*Lb.*	*Kg.*	*Lb.*	*M.*	*In.*
American:								
1								
2								
3 A								
B								
C								
D								
E								
F								
4 A								
B								
C								
D								
5	Long point shell	Naval	317.73	700	10.98	24.2	0.9672	38.08
6 A	H. E. shell	Land	317.73	700	41.03	90.4		
B								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
German:								
17								
18								
19								
20								
21								
22								

NOTES.

[*] Approximate.
[a] For firing beams only—time for laying of.
[b] For ground platform.
[c] Can likewise be fired from wheels.
[d] Mount is held by wedges.
[e] On track.
[f] Ground platform.
[g] Concrete.
[h] Steel.
[i] Turntable type.
[j] On truck.
[k] For land projectiles.
[m] For seacoast projectiles.
[n] Variable—see diagram.

APPENDIX I.

THE GERMAN LONG RANGE GUN (43).

FIRST DAY'S BOMBARDMENT—FIRST IMPRESSIONS.

690. At 7.15 on the morning of March 23, 1918, just two days after the Germans opened their offensive against the British Fifth Army before Amiens, the people of Paris were startled by an explosion of something that had fallen on the Quai de Seine. The explosion was of such magnitude that it could be heard over practically the whole of Paris. Fifteen minutes later there occurred another explosion of the same magnitude, but this time closer to the Seine on the Rue Charles V; 15 minutes later another explosion occurred on the Boulevard de Strasbourg near the Gare de l'Est. Until that time Paris had never been bombarded except from airplanes and Zeppelins, and the first thought of the people was that they were being bombarded from some new type of aircraft that was being operated at such a height that it was practically invisible.

691. The explosions continued to occur throughout the morning at very uniform intervals of 15 minutes, and by evening 21 explosions had occurred at the places shown on plate 509. These are mentioned by their exact location under March 23 in the table given as plate 510. After the first few explosions between 7 and 8 o'clock in the morning, business in Paris practically ceased. Stores were closed and part of the Metro system ceased to operate; ticket offices in some of the railway stations were closed, and great numbers of people could be seen walking the streets looking skyward trying to locate the planes that were dropping the supposed bombs.

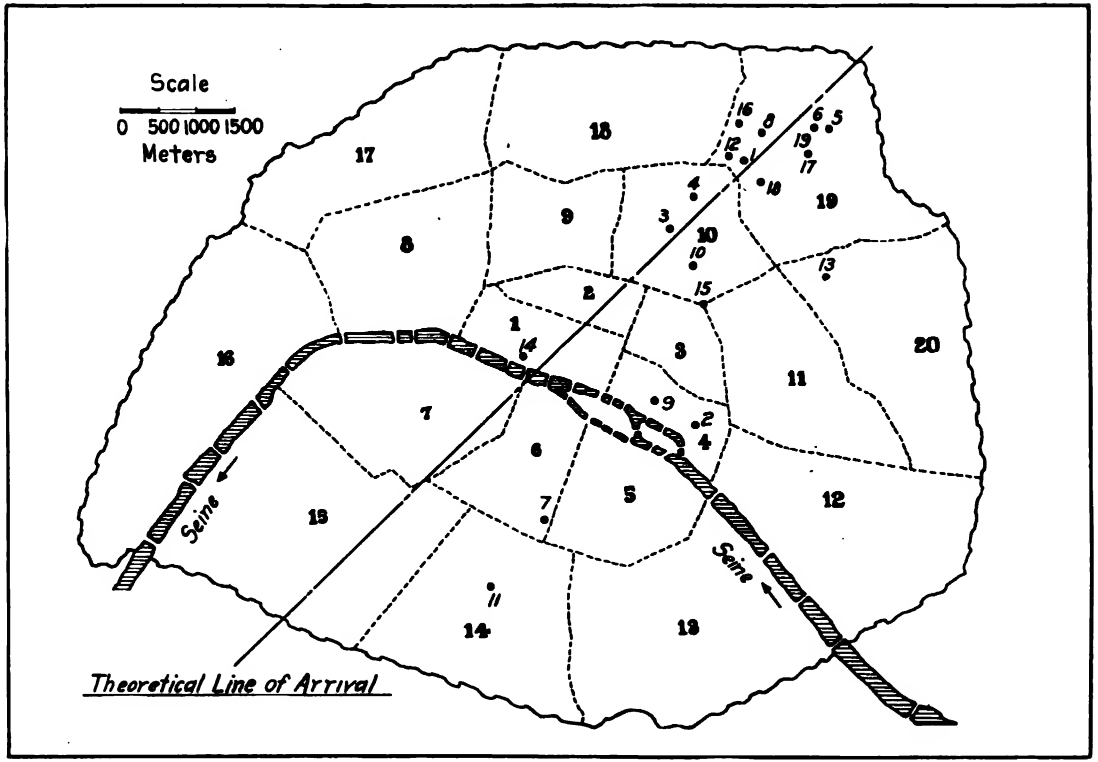
692. Information of the extraordinary bombardment was telephoned and telegraphed over practically the whole of France within a few hours and was received everywhere in amazement. After a few hours on the first day a sufficient number of the fragments of the exploding agent were collected by officials in Paris to identify it as a projectile being fired from a gun, rather than a bomb being dropped from an airplane. By noon representatives of the Heavy Artillery Section of the Ordnance Department, located at Tours, had made preliminary calculations in response to telephone instructions from Paris, giving the probable muzzle velocity at which a

projectile would have to start in order that it might travel from a few kilometers within a point of the German lines nearest Paris to the center of Paris. Inquiries were made likewise of the section as to the possibility that these projectiles could actually be coming from a gun within the German lines. The reply was that the probable muzzle velocity of the projectile, if it was actually being fired within the German lines, was not less than 4,500 feet per second. No such muzzle velocity had, to their knowledge, ever been realized, but with a gun of sufficient length and with a powder burning at a satisfactorily low speed, it was considered quite possible that the projectiles were being fired from within the German lines. By the end of the first day, officers of the French as well as the American Armies were quite certain that the projectiles were being fired from a newly designed long range gun, located within the German lines, and operating at a probable range of 110 kilometers (68.8 miles).

693. During the next few days some interesting theories were advanced in the various newspapers. In one case it was maintained that the projectiles which arrived in Paris were being fired from another much larger projectile, which actually served as a gun. This larger projectile was said to have been fired from a gun within the German lines and upon attaining a certain height, a charge of powder within the larger projectile was automatically ignited, firing the smaller one to a much greater distance. The theory that the projectiles were being fired from guns concealed in abandoned quarries or in heavily wooded regions near Paris received considerable credence and diligent search was made of all such places to be certain that it was not true. A third theory was that the projectiles were being fired from a pneumatic gun located within Paris.

694. A plotting of all the bursts for the first day showed results that were very puzzling. If the guns were being operated at comparatively short distances, the only way to account for the tremendous dispersion was on a basis of actual laying of the gun for different objectives. This theory did not seem plausible, however, because if the gun was actually laid on given objectives, these objectives were of relatively small importance. If, on the other hand, the projectiles were being fired from a gun at a great distance, it was seen at once that the dispersion was so great as to make it practically impossible to hit with any certainty any objective much smaller than that portion of Paris within the walls. It was noticed that the dispersion in direction, that is, to the right or left of the theoretical line on which the projectiles were arriving, was comparatively small, while the dispersion in range, that is, over or under the probable point at which the projectiles were supposed to arrive, was very great. Examination of the map, plate 488, shows that on this

PLATE 488



LOCATION OF BURSTS ON FIRST DAY OF THE LONG-RANGE GUN BOMBARDMENT OF PARIS.

first day, when the gun was new, the average dispersion in range was very small compared with the dispersion on later days when the gun became worn.

695. Evidence received later indicates that at the end of this first day's bombardment the first gun was about half worn out. Eighteen projectiles had fallen within the walls of Paris and 3 outside; 15 people had been killed and 36 had been wounded. The destruction of property had been comparatively small. By "comparatively" it is meant that the destruction was small in comparison with that wrought by the 100 and 300 kilogram airplane bombs. Whenever the projectiles landed in the street or in an open plot of ground, the hole made was seldom more than from 12 to 15 feet in diameter and from 4 to 6 feet in depth. When the projectiles struck buildings it was not unusual to have them explode in the interior without showing any considerable signs of damage on the outside.

696. On the 24th of March 13 projectiles fell within the walls of Paris and 9 without, killing 11 people and wounding 34. On the 25th 4 projectiles fell within the city and 2 without. This was the end of the first gun. It was worn out, and no more firing was done until the 29th, when the second gun began its work.

697. Search of the files of the French War Office revealed the fact that full drawings and plans had been on hand for quite a long time for just such a gun as the Germans were probably using. These specifications had been submitted several years before and had been discarded because of the excessive expense and the tremendous difficulties involved in manufacturing such a gun. It was considered likewise by those who had turned down the specifications that the value of such a gun was extremely questionable. It was realized that its dispersion would be excessive and that with the powders with which the service was then familiar it would be exceedingly difficult to secure a muzzle velocity sufficiently uniform to do effective work.

DETAILS OF THE BOMBARDMENT.

698. When the bombardment was over, an examination of the period over which it had extended indicated that it had been divided into three distinct series. The first extended from March 23 to May 1, the second from May 27 to June 11, and the third from July 15 to August 9. It seems certain that this division into series was a part of the plan of the large offensives being waged during that time. The table, pages 751 and 752, gives the bombardment by days during this entire period and shows the number of projectiles falling within and without the walls of Paris each day, the number of people killed and wounded, and the exact places where the projectiles fell. During the first few days of the bombardment the first projectiles arrived between 7 and 8

o'clock in the morning and continued to fall at intervals of 15 minutes through a portion of the day. On later days the bombardment would begin at 12.40 noon.

699. Much has been said with reference to the effect of this bombardment on the people of the city of Paris. The writer's first direct acquaintance with the bombardment was during the third and fifth days. With considerable surprise it was observed that already the people were taking it quite philosophically; in fact it could not be seen that they were paying much attention to it at all. At intervals of about 15 minutes muffled explosions would be heard in different parts of the city, seldom two consecutive explosions in the same vicinity. Many people would stop for an instant and attempt to decide from what direction the sound had come, after which they would go on their way apparently unconcerned. It was, of course, still sufficiently novel to be of considerable interest, and people were talking about it everywhere. It is quite probable that the regularity with which the projectiles were arriving got on the nerves of some people, and that the bombardment was responsible for the departure of some of the people who were crowding the trains west and south from Paris. It seems more certain, however, that by the 1st of June the close proximity of the Germans to the city of Paris, together with the anxiety caused by another drive impending, added to the effect of the heavy bombardments from airplanes on every clear night, had far more effect than the gun. The visible destruction of property was so slight as to give little evidence to anybody traveling about the city that the explosions they were hearing from time to time amounted to anything. The newspapers were very careful to avoid any discussion or even a lengthy reference to the bombardment from day to day, and neither gave the locations of the places where the projectiles had fallen nor the number of killed or wounded.

700. The Germans must certainly have known that their gun was not a profitable investment for the destruction of property; hence they must have continued the bombardment purely for its destructive effect on the morale of the Parisians and its beneficial effect on the morale of the Germans. This is likely the purpose which prompted the construction of the guns. In his book, "My Thoughts and Actions," Gen. Ludendorf says: "During the battle we had commenced bombarding Paris from near Laon with a gun having a range of 75 miles. This gun was a marvelous product of technical skill and science, a masterpiece of the firm of Krupp and its director, Rausenberger. The bombardment made a great impression on Paris and on all France. Part of the population left the capital, and so increased the alarm caused by our successes." He is right; the bombardment did make a great impression; it made everyone more angry and alarmed very few. It is certain now that they

could ill afford to use their manufacturing facilities for the making of such guns as these at a time when they were so desperately in need of heavy field guns to assist their armies in their big drives.

701. Long-range or super guns received consideration from the Allies for a very short period. There was a tendency for a few weeks to favor the construction of a great number of them, but a saner view soon prevailed, and actual steps were taken for the construction of only a very few. Both the British and the French Governments began the construction of a few, some of which have now been finished. They built them, however, with a clear understanding that they could hope for but little more from them than the Germans were getting from their own. American Ordnance officers feel that it would not profit us to construct more than two or three such guns at most and probably none at all.

702. Within a very few days from the beginning of the bombardment it was possible through careful examination of the direction of the passage of the projectiles through various buildings, to determine quite accurately the direction of their arrival and the probable place from which they were coming. This place was in the Forest of Gobain, west of Laon. Very soon thereafter the French Air Service was able to locate in this same forest three positions, from any one of which, or possibly from all of which, the guns were being operated. Only one of these were sufficiently close to the German and allied lines to permit of any possibility of operating against it with the heavy guns then in service. The gun selected was a 34 centimeter (13.38 inches), 45-caliber French gun on a railway mount. This mount was run up to a point very close to the lines and behind a hill of such size as to effectively conceal it from German line observers. It was well camouflaged by nets against the air observer and against German sound ranging apparatus by placing two smaller guns at the right and left and several hundred yards behind it. These smaller guns were fired at intervals of one and two seconds before the larger gun, and evidently had the effect of so disturbing the German sound ranging apparatus as to make it impossible to locate the heavy gun. After a half day's firing from the 34-centimeter gun, air photographs indicated that the emplacement had been destroyed. The airmen undertook to demolish the other two emplacements and their photographs indicated that they had inflicted considerable damage. Apparently they did not secure any direct hits for the gun or guns continued to fire without any long intervals.

703. After the advance of the Allies it was impossible to determine from examination of the emplacement which had been nearest the allied lines whether a gun had actually been on this position or not. A German artillery officer who worked with the Americans for sometime in the forward area after the armistice and who spoke with such

certain knowledge of the long range gun as to indicate that he knew the details of design and had seen it, insisted that the position that had been destroyed by the Allies had not had any gun on it.

704. Mention has already been made of the destruction of property by these long range projectiles. Except in a few places where the damage was so exposed as to attract attention, no matter how slight it might be, there was little evidence that the bombardment had any effect. On March 29, the day on which the second gun began to fire, and fired only four projectiles, the one projectile which landed within the city of Paris struck and knocked out the keystone of one of the arches in the roof of the Church of St. Gervais near the Hotel de Ville. The falling of the keystone caused a large part of the arch and the roof to collapse and most unfortunately the church was quite full of people at the time. Examination of the table below shows that this day holds the record for casualties. On one other occasion a projectile burst in the lobby of a hotel, killing a number of people, but doing comparatively little material damage. Some idea of the damage ordinarily wrought can be gained from examination of plate 489. This shows the hole made by the explosion of one of the shells in the Garden of the Tuilleries. It will be noted that the wall is not damaged and that only a comparatively small hole has been made in the ground.

The bombardment of Paris by the German long-range gun, Mar. 23 to Aug. 9, 1918.

Dates.	Number of projectiles.		Killed.	Wounded.
	Within the walls.	Outside the walls.		
Mar. 23	18	3	15	36
24	13	9	11	34
25	4	2	1	3
29	[1] 1	3	[1] 88	68
30	18	3	10	60
31	3		1	1
Apr. 1	3	1	8	8
2	3	1		3
3	1			
6	2	4		3
7		1		
11	5	1	9	21
12	5	2	2	14
13 [2]	6	2		
14	3	1		
15 [3]	3	2		
16	2	1	17	114
19	1	2		
21	2			
24		1		
25	6	4	1	
26 [3]	1			
30		3		
May 1		1		5
27 [3]	7	7	4	20
28	6	4	1	2
29	5	5	1	7
30	4	5	13	5
31	1	3		
June 1		4		

[1] Shell struck an arch in the roof of the Church of St. Gervais. [2] Night and day. [3] Night.

PLATE 489

SHELL HOLE IN THE GARDEN OF THE TUILLERIES.

The bombardment of Paris by the German long-range gun, Mar. 23 to Aug. 9, 1918—Con.

Dates.	Number of projectiles. Within the walls.	Number of projectiles. Outside the walls.	Killed.	Wounded.
June 3	....	6	2	8
4	4	....	4	16
7	3	1	1	4
8	1	2	3	....
9	1	3	1	9
10	2	2	3	13
11	....	1	....	....
July 15	9	1	6	9
16	4	....	3	8
Aug. 5	13	4	32	61
6	12	7	8	39
7	8	4	7	43
8	1	4	1	....
9	2	10	3	6
Total	183	120	256	620

705. Even during the active periods of the three series noted above there were many days on which the gun did not fire. It is quite certain that between the 25th and 29th of March the first gun was being removed and a new one placed on the carriage. By the end of the 25th of March 49 projectiles had arrived, and the probable life of the guns is not more than 50 rounds. It is likely that the guns were changed again between the 7th and 11th of April and between the 21st and 24th of April.

706. After the armistice it was learned that the Germans had constructed a total of seven guns. These guns were first constructed to a diameter of 21 centimeters (8.27 inches) and after being worn out as 21-centimeter guns were being rebored to 24 centimeters (9.45 inches). All of the projectiles of the first two series were 21 centimeters in diameter, but during the last days of the third series the projectiles were 24 centimeters in diameter, indicating that the entire seven guns had been worn out, and that probably the gun that had commenced firing on Paris on March 23 as a 21-centimeter gun had been rebored and was fired again as a 24-centimeter gun. It was learned also that the Germans were reboring the remainder of the seven guns and were constructing additional guns at Essen. Representatives of the Ordnance Department found in the Skoda Works at Pilsen three more guns which the engineer at these works said were under construction as long-range guns at the time of the armistice. In July, 1918, the Intelligence Service transmitted information to the effect that one gun had been destroyed by a premature explosion. No confirmation of this report has ever been found and it can not be considered a certainty.

707. The third series began on July 15 with 10 projectiles, followed by 4 projectiles on the 16th. The bombardment then ceased for three

weeks, beginning again on August 5 and continuing daily until the 9th. On this day 12 projectiles arrived, only two of which fell within the walls of Paris. The famous bombardment was finished. A comparison of the distribution of the bursts on this last day, plate 490, with the locations on the first day, plate 488, is very interesting. On the first day a considerable portion of the projectiles fell within a very small area in the northeastern section of Paris. On this last day it will be observed that they are scattered over the eastern section of Paris and no two are very close together. The last projectiles of the entire bombardment fell between 1 and 2 o'clock on August 9. Already the Allies in their successful drive north of the Marne and between Soissons and Rheims were driving the Germans back so rapidly and had made such progress as to put the long-range guns in serious danger.

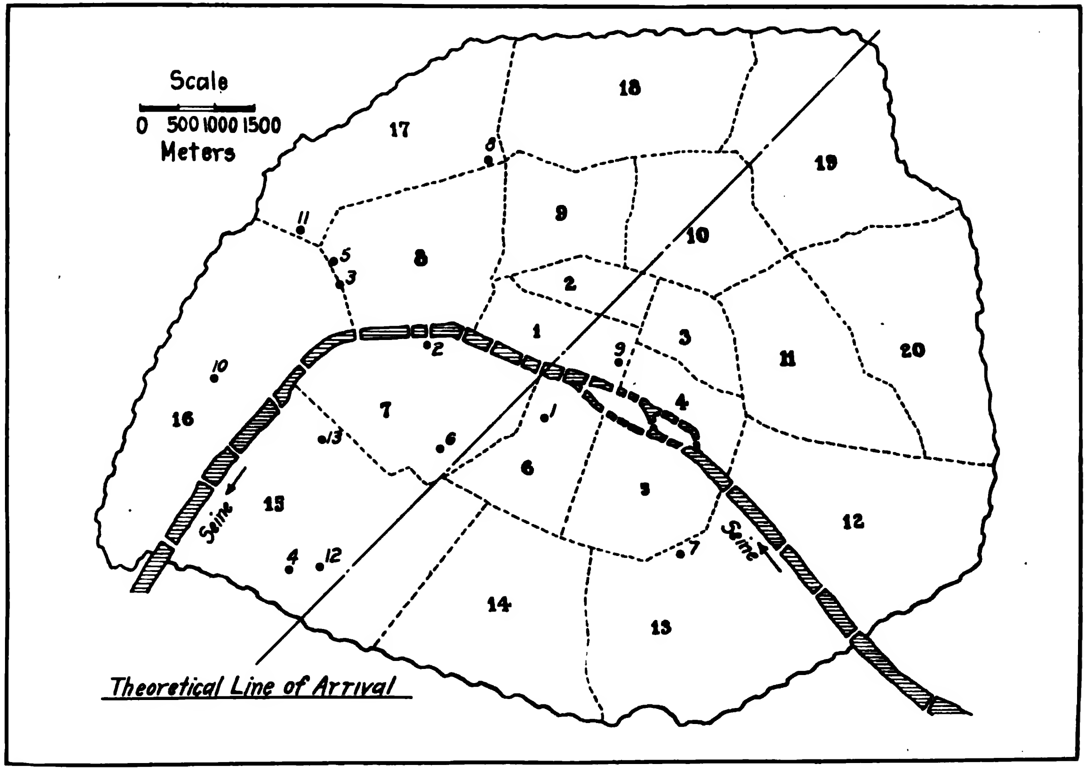
708. Plate 491 shows the location of all of the bursts within the walls of the city, a total of 183; 120 more fell outside the city, making a total of 303 fired from seven 21-centimeter guns and probably one gun rebored to 24 centimeters. The bombardment included 44 active days. Even before the last day of the bombardment American forces operating north of the Marne had captured an emplacement 9 kilometers (5 miles) north of Chateau-Thierry. This emplacement will be described in detail later. It was 86 kilometers (53.4 miles) from Paris and it is understood that it was a new emplacement from which the Germans had hoped to operate the super guns more effectively.

DESIGN OF THE GUN, CARRIAGE, AND EMPLACEMENT.

709. Introduction.—It has been mentioned before that the Germans used seven guns of a caliber of 21 centimeters (8.27 inches), that they had rebored at least one of them to 24 centimeters (9.45 inches), and that at the time of the armistice three more guns were under construction at the Skoda Ordnance Works at Pilsen in Austria. During the period of active warfare many reports were received with reference to the design of the gun, but never any information with reference to the carriage. The various reports on the gun agreed quite closely in the essential details.

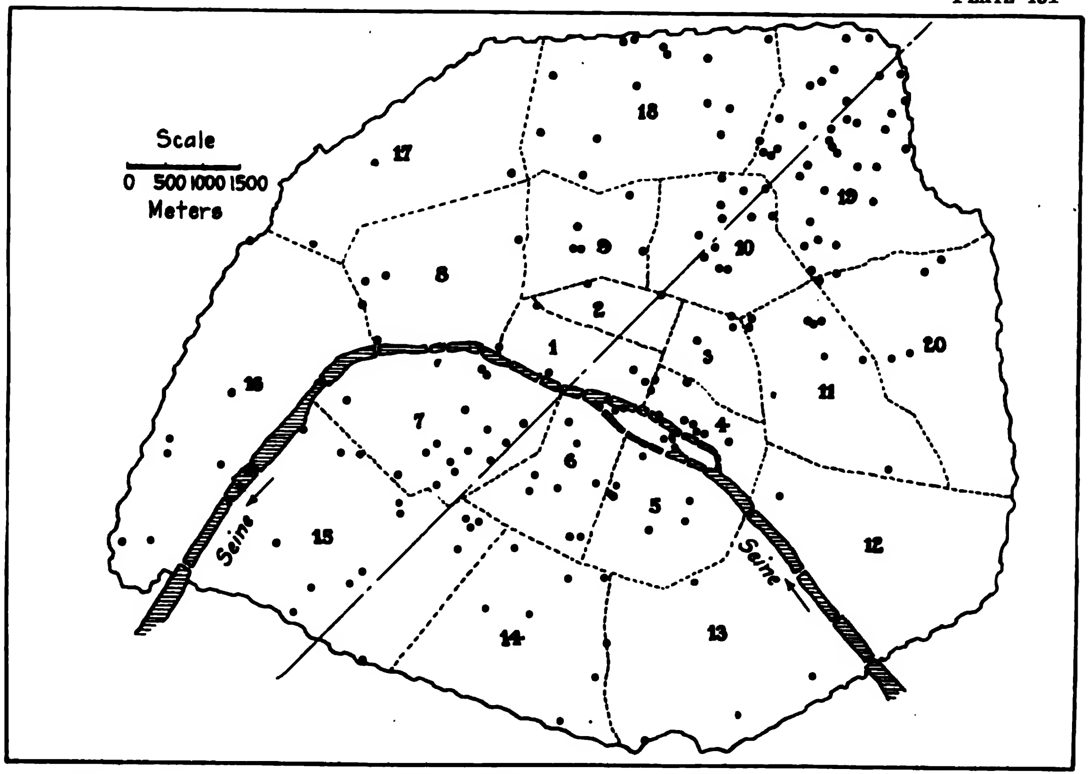
710. In May, 1919, a commission of Ordnance officers was sent to the Skoda Works in Austria for the purpose of investigating their methods of constructing large and small ordnance. While there they secured additional data from the chief engineer of the plant with reference to the design of the gun, and saw the three guns which had been in process of construction on November 11, 1918. This chief engineer stated that when the first German gun began to fire on Paris, it was as much a surprise to the Austrians as it was to the Allies. Shortly thereafter he went to France to examine the gun and observed

PLATE 490



LOCATION OF THE BURSTS ON AUGUST 5, 1918.

Plate 491



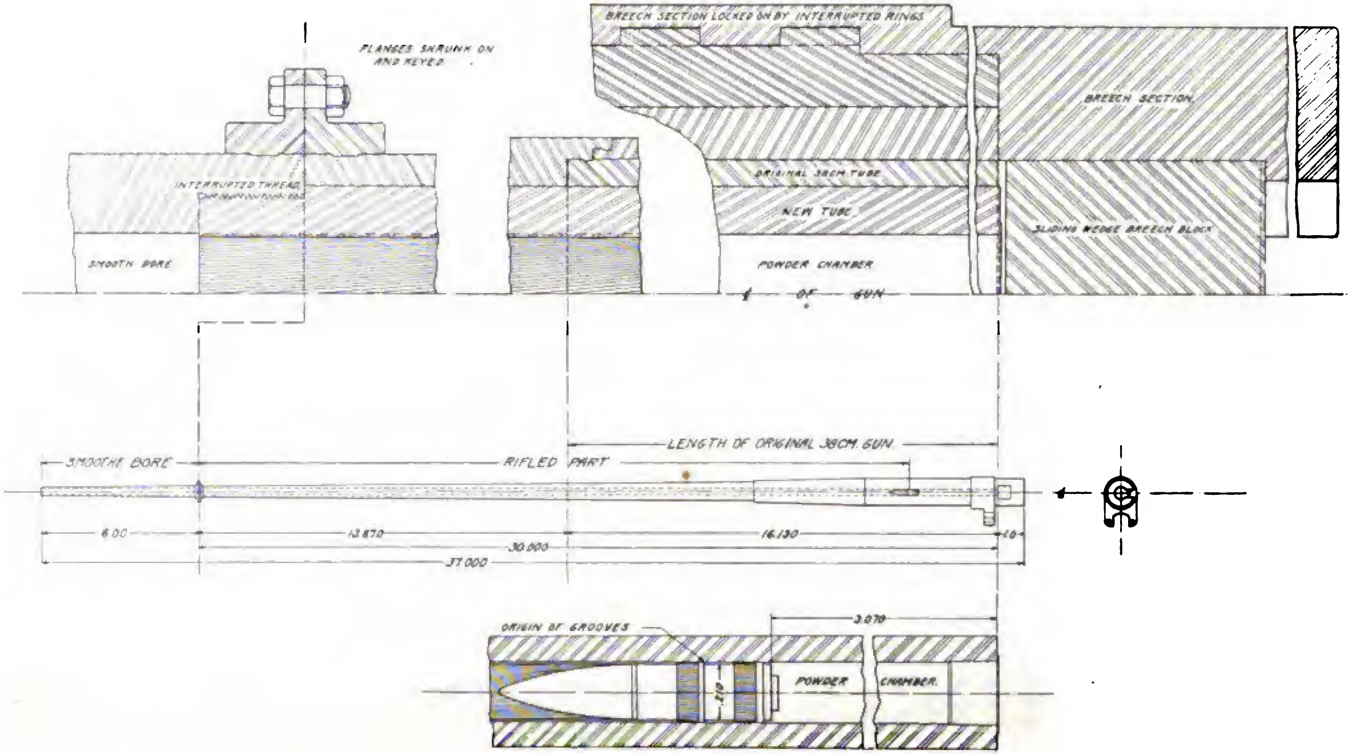
LOCATION OF ALL THE BURSTS WITHIN THE WALLS OF PARIS.

it in action. It was not until a few months before the armistice that the three guns were sent to Pilsen for conversion into long-range guns. Evidently the Germans had considered the bombardment a success, or sufficiently so to warrant the use of manufacturing facilities for the construction of a greater number of guns than they were able to handle at the Krupp Works at Essen.

711. The details of the design of the carriage for the gun were not learned until April, 1919, although it had been quite certain since August, 1918, that the emplacement found north of Chateau-Thierry was intended for the carriage of the long range gun. Until July 1, 1919, no direct information had been received from the Germans with reference to the design of any part of the entire mechanism except the gun on which, as mentioned before, information had been received at various times before the armistice; the guns themselves were examined at the Skoda Works at Pilsen. Just why the Germans refused to talk about this gun is not known. In December, January, and February, 1918 and 1919, a German engineer who was working with the American forces in the region northeast of Verdun helping identify long delay fuses and assisting on other technical matters said that he was acquainted with the design of the gun and had seen it in operation. Very curiously, however, he refused to give any information with reference to the details of the design; was quite positive in his assertions that the Allies would never see any of the guns, and certainly not any of the carriages. This was difficult to understand in view of his perfect willingness to talk about the details of design of any other piece of ordnance that he was at any time asked about, and it was more curious in view of the fact that there is really nothing wonderful about the design of the long-range gun, its carriage, or its emplacement.

712. Gun.—All of the long-range guns were constructed from worn-out 38-centimeter (15-inch), 45-caliber guns (17.1 meters or 56 feet in length). The converted gun was in two parts, the main section 30 meters (98.5 feet) in length and the forward section 6 meters (19.7 feet) in length. The 38-centimeter gun was bored out and a very heavy tube with inside diameter of 21 centimeters was inserted; 12.9 meters (42.3 feet) projected beyond the end of the original gun and over this projecting portion another hoop was shrunk and locked to the forward hoop of the old gun. This 21-centimeter tube was rifled at a uniform twist throughout its length. The other section, 6 meters in length, was attached by means of an interrupted thread and heavy outside collars or flanges. This section was unrifled and was of an inside diameter equal to 21 centimeters plus twice the depth of the grooves in the rifled section. It was assembled to the gun in the field and not removed until the gun had been worn out. The total weight of the original 38-centimeter gun was 152,550

PLATE 492



DETAILS OF THE DESIGN OF THE 210-MM. GERMAN LONG-RANGE GUN.

pounds and the weight of the reconstructed gun approximately 318,000 pounds. The 21-centimeter liner was of such thickness that on being worn out at this caliber it could be rebored first to 24 centimeters (9.45 inches) and later to 26 centimeters (10.024 inches). Its probable life at any one caliber was not more than 50 rounds and the maximum powder pressure did not exceed 3,000 atmospheres or 44,000 pounds per square inch. The design of the breech mechanism of the original 38-centimeter gun did not require modification.

713. The long-range guns constructed by the British and French Governments do not follow the German design to the extent of having a smooth-bore section on the front. The purpose of this feature was for some time in doubt and is worthy of some discussion.

714. The gun just described is approximately 3 meters longer than either the British or French long-range guns, both of which are rifled throughout their length. Two reasons might be given for the extra section.

715. Possibly additional linear velocity was imparted to the projectile as it traveled through the 6-meter smoothbore section. It seems improbable, however, that this could be its primary purpose, inasmuch as the muzzle velocity was such a variable quantity. It is more probable that its purpose was to align the axis of the projectile more perfectly with the axis of the bore of the gun and reduce to a minimum the angular velocity of yaw as the projectile left the muzzle. When it is understood that this projectile was to mount to a height of about 24 miles and travel a horizontal distance of 76 miles, it can easily be appreciated that any tendency that the projectile might have to throw its axis out of alignment with its theoretical path would have disastrous results. Through the impracticability of making projectiles fit perfectly in a gun, they have a tendency to hammer the walls as they travel down the bore. This hammering action of the projectile is the result of the operation of two forces, the one tending to increase its linear velocity and the other to increase its rotational velocity. The latter force is acting only while it is traveling through the rifled section. It is invariably true that just as the projectile is leaving the ordinary gun it is on one of its up, down, or crosswise hammer strokes, and that the axis has a tendency to yaw or deviate from its theoretical path at a certain angular velocity. Cardboard screens placed in front of guns in proof firing invariably show elongated holes, and not infrequently very decidedly so, even at no greater distances than a hundred feet from the muzzle. This tendency to yaw has a detrimental effect on the accuracy of even our comparatively short-range guns, but no effective means have yet been devised to neutralize it. With the extreme range gun it is so much more serious that it seems quite likely that the Germans adopted this method of neutralizing it,

thereby reducing the dispersion both in range and in direction. It is not improbable that the German gun was first constructed without the smoothbore section and that its shooting was found to be so erratic as to require the addition of this feature.

716. This gun was operated at a muzzle velocity of from 1,500 meters (4,920 feet) to 1,600 meters (5,248 feet) per second and at an elevation of 55 degrees. This 55 degrees is worthy of comment inasmuch as it has ordinarily been supposed that nothing could be gained in range by elevating a gun above 45 degrees. It is known, of course, that if a projectile is fired in a vacuum its maximum range is attained when it starts at an elevation of 45 degrees. When fired in the air, however, the initial angle which permits it to attain its maximum range depends both on the caliber and weight of the projectile, and the velocity at which it leaves the gun. With reasonably large and well-designed projectiles it may be said that for each muzzle velocity (A) there is a density of air (b) into which the projectile should enter at an approximate angle of 45 degrees. For this projectile and the muzzle velocity of 1,500 meters per second the initial angle is 55 degrees. It is very doubtful whether any additional range can be secured with any projectile at any muzzle velocity at an angle above 55 degrees.

717. Attention was called in the discussion of the first day's bombardment to the tremendous dispersion in range. Some of the projectiles fell just within the wall at the northeast side of Paris, and some within the walls at the southwest side. This is accounted for by the fact just mentioned, that the muzzle velocity of the projectile varied as much as 100 meters per second. It was impossible with the powder that the Germans were using to secure a muzzle velocity with a variation of less than 100 meters per second.

718. Cradle.—The cradle is a cylinder of simple design having ribs at long intervals and of a depth of only about 3 centimeters, plate 410. The walls of the cylinder have a minimum thickness of 10 centimeters and a maximum thickness of 13 centimeters over the ribs. The diameter of the main trunnion is 46 centimeters, and the length 33.5 centimeters. A collapsible counterweight is attached to the top of the cradle. In firing, the two sections of this counterweight are raised and locked together for the purpose of raising the center of gravity to such an extent that the gun may be elevated and depressed more easily. This cradle is of a naval design, the front section being so shaped as to close the opening in a turret. It is not improbable that the cradle as well as most of the 38-centimeter guns were removed from German ships or coast fortifications.

719. Recoil Mechanism.—The recoil mechanism is composed of two hydraulic recoil cylinders and one spring-pneumatic recuperator cylinder, all attached to the bottom of the cradle, plate 403. Each of

the recoil cylinders is a separate cylinder carried in brackets cast on the cradle, and each is provided with a buffer approximately 32 centimeters long. The plugs through which the cylinders are filled are on the ends of the buffers. The approximate length of recoil is 1.3 meters (50.5 inches). This distance is of course approximate and was arrived at after careful examination of the cradle. A report examined in the office of the Chief of Artillery of the Belgian Army at Brussels gives the length of recoil as 1.16 meters. Inquiry disclosed the fact that this length of recoil was approximate also.

720. Two rods screwed to the recoil lug of the gun, plates 403 and 405, and extending to the rear, carry a heavy crosshead to which the piston of the recuperator cylinder is attached. The recuperator cylinder is likewise a separate cylinder carried in brackets cast on the cradle. At the rear on both sides it is planed to serve as a guide for the recoil lug to prevent rotation of the gun.

721. Elevating Mechanism.—The elevating mechanism of this mount is extremely heavy and unique in design. The cradle was evidently originally provided with the screw type of elevating mechanism, the screw being hinged to the cradle at the rear end.

722. The specification that the gun be provided with an elevation of 55 degrees necessarily led to the discarding of the screw mechanism. The straight racks shown on plates 400, 407, 408, 409 slide in ways which are parallel to the inclined forward ends of lower chords of the side girders. It was necessary to put them in this position to secure sufficient movement to attain 55 degrees. At the lower end they are connected with each other by a heavy shaft to which are attached the two connecting rods running up to the bottom of the cradle, plate 409. Provision is made for two handles on each side of the car, each for two men, plate 409, and a two-speed transmission is provided, permitting the mechanism to be operated at low or high speed. The ratio of the gearing at low speed is 4⅛ turns of the handle for 1 degree of movement of the gun. It was not possible to determine the ratio of high speed since the two men making the examination could not operate it. It seems probable, however, that eight men could operate the mechanism at high speed without undue difficulty.

723. Traversing Mechanism.—(See "Anchorage.")

724. Railway Car Body.—The railway car body shown on plates 400, 413, 415, 416 is made up of two single-web side girders connected at the front and rear by heavy structural steel transoms. They are further reenforced in the front by the heavy cast-steel housing for the elevating gear. The trunnion seats are of cast steel and are simply bolted to the top chord with single-key plates at their rear. This single-key plate has the positive backing of one top-cover plate. The face of the horizontal section of the lower chord of the side girders is planed and is provided with key plates at each end, plate 416. Eight

2-inch holes are provided in each lower chord at the front end and six at the rear for bolting the mount to the emplacement.

725. ANCHORAGE.—When the German army had retired from the salient between Soissons and Rheims in August, 1918, the emplacement shown on plates 417 and 418 was found in the Bois du Chatelet, 9 kilometers directly north of Chateau Thierry. This emplacement was in process of installation and had not been completely erected. The Germans attempted to destroy it, but succeeded only in ripping loose a few plates. At the time the emplacement was captured no description of any kind was available of the carriage for which it was intended. The writer's failure to find any emplacement in Belgium from which the mount examined there could be operated, led to further examination of the emplacement in France, and it was found that they fitted perfectly.

726. The emplacement is in two main sections, one a base and the other a rotating section. The rotating section, plates 419 and 420, is about 28 feet 6 inches in diameter and is supported on 112 8-inch steel balls. The base is about 35 feet in diameter and 6 feet in depth. On plate 417 there can be seen at right angles to the direction of the track of the rotating section two girders, on the ends of which are key plates or pads. The plate which is labeled has six holes in it and the plate on the opposite end of the girder has eight.

727. The mount is run onto the emplacement with the rotating section in the position shown in plate 420. It is then raised by the four jacks which can be seen at the left of plate 417, and are shown in their exact positions in plate 420. When the mount is raised the trucks are removed and the rotating section of the emplacement turned through 90 degrees. On lowering the mount onto the emplacement, the key plates on the bottom chords of the carriage are fitted to the corresponding key plates on the emplacement. The emplacement is shown in process of installation, with the Gantry crane still in place, plate 421.

728. The carriage on which the gun is so mounted as to be capable of movement in a vertical plane only, is traversed by rotating the top section of the emplacement. A complete circular traversing rack made up of angles and steel pins is bolted to the structural base, plate 422. A pinion carried on a vertical shaft on the side of the rotating section which corresponds to the rear of the carriage engages with this rack and the mechanism is driven by two-man handles on a horizontal shaft carrying a worm engaging with a worm wheel on the top of the vertical shaft, as shown at the right of the top view, figure 420. This shaft may likewise be driven by means of the four handles mounted on the two cases in the center of the rotating section and connected with the worm wheel and shaft through two shafts

carrying two universal joints each. Apparently the mount was generally traversed by means of these latter handles, if one may judge of the scheme of operation from plate 422.

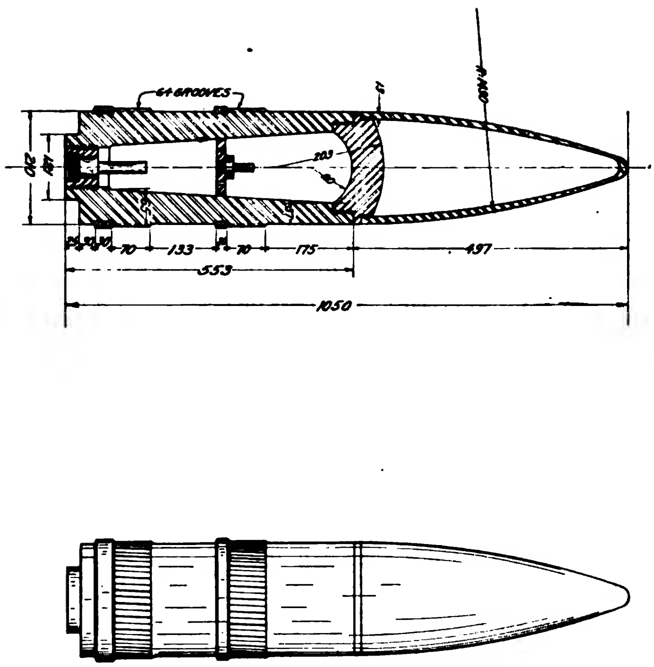
729. Camouflage.—In the case of the emplacement found in the Bois du Chatelet, sockets were placed in the center of the approach track at intervals of about 30 feet, into which trees with trunks up to about 6 inches in diameter could be placed for the purpose of concealing these tracks. The Gantry crane, as well as the emplacement, while in the process of installation, were covered with tree branches, plate 421, and raffia nets were stretched over the mount from the trees on either side, plate 422.

730. Trucks.—All of the trucks as well as the span bolsters are constructed entirely of structural steel, as shown on plate 423. The front trucks contain five axles each, and the rear trucks four axles each. The journals are approximately 14 centimeters in diamteer by 22 centimeters in length. The wheels are 95 centimeters in diameter. On the front trucks three wheels are provided with two brake shoes each; on the rear trucks the end wheels are provided with two shoes each and the inner wheels with one shoe each. The braking is done by hand only. The axles are equalized in pairs only. The center axles of the front trucks have no connection with the others. On plate 400 a portion of a circular rail can be seen on the top of the front truck on which the pads attached to the span bolster on each side bear.

731. Ammunition Supply System.—The provisions made for supplying ammunition are shown on plates 424, 425, and 426. These same provisions were used for the operation of the 38 centimeter, 45-caliber naval guns from which the long range guns were made. The extension of the car body shown on plate 426 was used for the operation of the 38-centimeter gun under certain conditions. This was not required and was removed when the long-range gun was operated on the carriage. On plate 425 a removable plate can be seen between the shot truck rails. Above this removable plate is a light bridge in the center of which is seen a ball on the end of the cable used in hoisting projectiles through the hole in the floor. This cable runs over a series of pulleys to a small drum in the box on the top of the left side girder. The ammunition was supplied from the storehouse over the narrow-gauge track shown on plate 424, the circular portion of the track being under the opening in the center of the floor of the mount. The gear in the box on the side girder is of the double speed variety, the high speed being provided probably for rapid operation in the hoisting of powder.

732. Ammunition.—The projectile used with this gun is shown on plate 493. Its weight is 120 kilograms or 264 pounds. The length of the main portion of the projectile is 490 millimeters or approxi-

PLATE 493



DESIGN OF THE GERMAN LONG-RANGE PROJECTILE.

mately 19.3 inches. To this is attached a false ogive or cap, the exact length of which is not known; it is probably as long, if not slightly longer than the main portion of the projectile. The radius of the curve of this ogive is about 7 calibers or 58 inches. It will be noted that the charge is separated into two parts by a diaphragm which has a number of holes in it. Two fuses are used, the one in the diaphragm and the other in the base. All of these projectiles are most carefully machined to elaborate specifications in order that the weight and dimensions might be practically exact and the center of gravity perfectly located; even after they are thus machined they are sorted out into lots according to their characteristics by weight, dimensions, and location of the center of gravity and the various lots of projectiles marked with center punch marks. The necessary corrections in elevation and deflection are calculated for the projectiles of these various lots. The projectiles which fell in Paris were successively marked with three center punch marks in a triangle or four center punch marks in a square, etc.; projectiles of the same marking arrived consecutively.

733. The outside of the projectile is provided with two copper bands which served as gas checks and in front of each of these copper bands the projectile is enlarged and rifled for a length of 70 millimeters (2.7 inches). The shear from the extreme acceleration necessary to produce the required muzzle velocity is such that the ordinary copper bands could not be made to serve as rotating bands. The shearing strength of copper is not sufficient to stand the strain that would have been put on the bands with so great an acceleration. The friction between the lands of the gun and the projectile is so great as to wear the gun appreciably on each round fired. This was evident from examination of the copper bands of successive projectiles. As a result of the necessity for providing rifled projectiles, it is necessary in placing the projectiles in the bore of the gun to fit the forward rifled section of the projectile into the beginning of the rifling of the gun, plate 514. The exact details of the design of the portion of the tube between the beginning of the rifling and the powder chamber are not known. It seems quite probable, however, that there is a smooth section of about 12 inches into which the portion of the projectile back of the first copper band fits, bringing the base of the projectile to the end of the powder chamber. The fact that the forward rifled section of the projectile is already fitted into the grooves of the gun makes it certain that the rifled section at the rear would likewise fit as the projectile begins to move up the gun.

734. It has been noted before that this projectile departed at a muzzle velocity of from 1,500 to 1,600 meters per second. The velocity remaining on its arrival in Paris was approximately 700 meters per second and the time of flight about three minutes.

735. The analyses made of the various parts of the shell showed:

	Shell.[1]	Cap holder.[2]	Cap.	Diaphragm.[3]	Copper band.	Dunkirk shells.
C	0.43–0.85	0.58–0.73	0.10–0.18	0.60	....	0.72
Mn	.27– .49	.27– .36	.41– .97	.09	....	.26
Si	.24– .31	.19– .28	.03– .05	.61	....	.23
S	.04– .10	.03– .07	.05– .11	.04	....	03
P	.01– .06	.03– .07	.04– .067	.04	....	.04
Ni	1.82–2.32	2.10–2.39	.11	....	....	2.41
Cr	.83–1.45	.95–1.44	.2	....	....	1.32
Pb	....	....	....	....	0.12	....
Fe	....	....	....	....	.21	....
Cu	....	....	....	....	99.67	....

[1] Practically a casting. [2] Cast. [3] Forging.

736. Not a single one of the 303 projectiles that fell in or about Paris failed to detonate. Evidently the two fuses were responsible for this excellent record. The practice of separating the charges into two parts by a diaphragm is not new. The diaphragm had been used before in French heavy projectiles as a guarantee against the effects of inertia which might either provoke a premature explosion in consequence of the friction of the molecules of the charge against each other or might bring the charge beyond the critical density point after which it would probably not detonate. At one time a theory was advanced to the effect that this diaphragm separated two liquids which mixed and detonated upon the fall of the projectile. There seems no good reason to believe that this could have been so.

737. Previous Designs and Limits in Design.—It has already been mentioned that investigation disclosed shortly after the beginning of the bombardment that an almost identical design had been proposed to the French Government not many years before. Further search of French and English records has brought to light the fact that the rifled projectile is quite old and seems to antedate the copper band considerably. In 1892 Sir Alfred Noble made a 100-caliber 6-inch gun which gave a muzzle velocity of 3,700 feet per second; in the same year the French Government constructed a 10-centimeter 80-caliber gun from which they attained almost the same muzzle velocity. It is not known what range was secured in either case. The forms of most standard projectiles at that time was not such, however, as to make it possible to secure the maximum range from the above noted velocity.

738. In taking up the design of such guns again the French and English services found that with guns of practicable length and muzzle velocities attainable with guns of such length, and with available powders, the projectile that would permit the greater range to be realized would be approximately 8 inches in diameter and weigh from 225 to 250 pounds. An appreciable change up or down in the diameter or the weight of the projectile would result in a loss

of range. The gun designed by one of our allies uses a projectile weighing 240 pounds and a powder charge of 350 pounds. One of the pieces of powder examined was about 2.5 feet in length and roughly elliptical in cross section, the axes being about 1 inch and one-half inch, respectively. It is interesting to note in this case that the powder charge has a weight about 50 per cent greater than that of the projectile. If the weight of the charge were increased, calculations indicate that most of the energy of the gas would be absorbed in the work of accelerating the charge rather than in accelerating the projectile and no greater muzzle velocity would be obtained.

739. One of the vital requirements made of the powder is that it burns at a rate sufficiently slow to avoid excessive pressures and to give a uniform pressure through a large portion of the period of the travel of the projectile in the bore of the gun. The powder made by one of our allies for their long-range gun is in flat strips resembling cardboard. These strips are 3-ply, the various sections burning at different rates. The large sticks of powder mentioned above for the gun of the other of our allies is special and is expected to live up to the characteristics just noted.

APPENDIX II.

STUDY OF THE RELATIVE EFFICIENCY OF DIFFERENT CALIBERS.

740. Prior to the European war guns were not constructed above 50 or at most 55 calibers length, and, in general, for greater range, larger and larger calibers were employed. The German long-range gun emphasized the fact that such practice did not rest on any fundamental theoretical difficulty in making a smaller caliber shell carry to the greater range. The French, in their program for new guns of greater than the previous ranges, planned on fairly small calibers, and the question at once arises as to whether this is not a more economical plan than the old one of using a larger caliber.

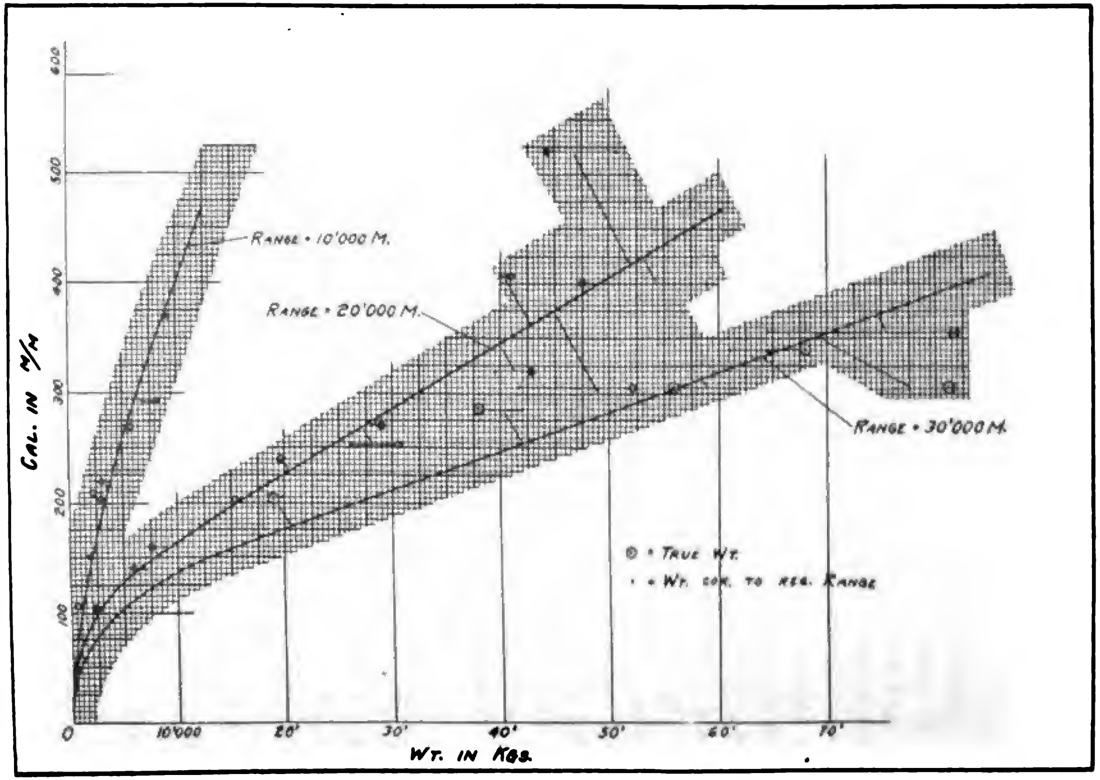
741. The following calculations are based on the assumption that it is desired to shoot a certain total weight of projectiles across a certain range into enemy territory, and that for this purpose, on account of the nature of the target, the number and caliber is immaterial (within limits), provided the total weight is the same. This is the condition that is believed to exist for fire upon industrial establishments, railway yards, ammunition dumps, and the like—in fact, for most of the targets that are presented for destruction at long range.

742. For this purpose, the three ranges of 10,000, 20,000, and 30,000 meters were taken, and data were obtained on French and American guns shooting, at maximum elevation, to these ranges.

743. First, the relation between caliber and weight of piece was studied. This relation is shown by the curves of plate 494, one curve being given for each range. As practically no guns were found which had a maximum range exactly that considered, a correction had to be made in each case, as indicated on the curve, the weight of gun was increased or decreased proportionately as its maximum range was below or above the range in question (10,000, 20,000, or 30,000 meters).

744. Next, the relation of life in rounds and caliber was studied. Life was computed from the Jones formula, using a corrected velocity, obtained similarly to the corrected weight. That these values of life are near to the absolute correct life may be seriously questioned. But for comparison between the different guns at the larger calibers, they are probably quite close, plate 495.

PLATE 494



DESIGN OF RELATION OF CALIBER TO GUN WEIGHT.

PLATE 495

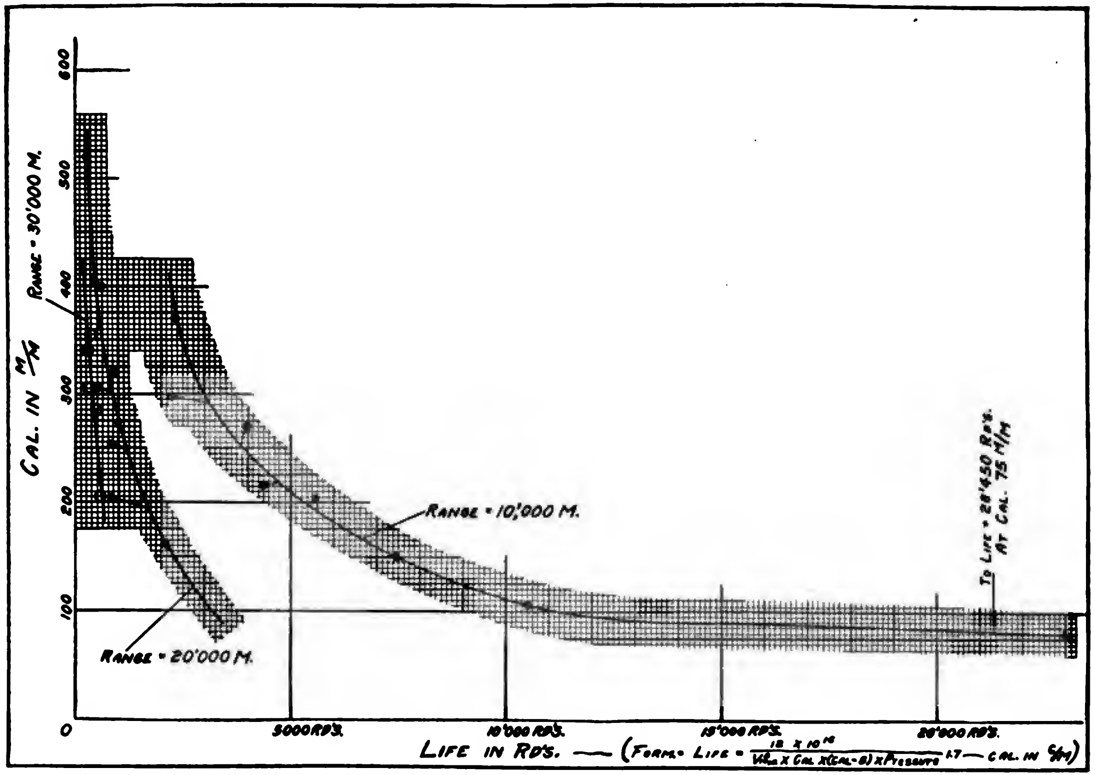


DIAGRAM OF RELATION OF CALIBER TO GUN LIFE.

745. A standard of 1,000 kilograms is taken as the weight of projectile to be delivered on the target. The number of shots necessary to accomplish this delivery for different calibers is approximately a cube curve, and is plotted from actual values on plate 496.

746. From the preceding data, it is now possible to calculate the weight of projectiles which each gun can deliver before it is worn out. This is shown on plate 497, the points representing computations from the actual values for the preceding guns and the curves, computations from values read off the previous curves.

747. It is now assumed that the entire weight of metal in the guns is used up when it is worn out, or that it becomes ineffective. Hence, if we compute the total weight of projectiles which can be delivered by each caliber per 1,000 kilograms of gun wear (computed as above noted), we have a direct measure of the relative efficiency and economy of the different calibers of guns at different ranges. This has been computed and plotted on plate 498. On this diagram there are shown also similar curves derived from purely theoretical considerations on a line of similar guns.

748. The conclusions from this are as follows:

(*a*) At 10,000 meters, it is much more economical to deliver a given total weight of projectile with the smallest practicable caliber. A given weight of 75's will deliver during their life three times the weight of projectiles to this range that the same weight of 400's would deliver during their life.

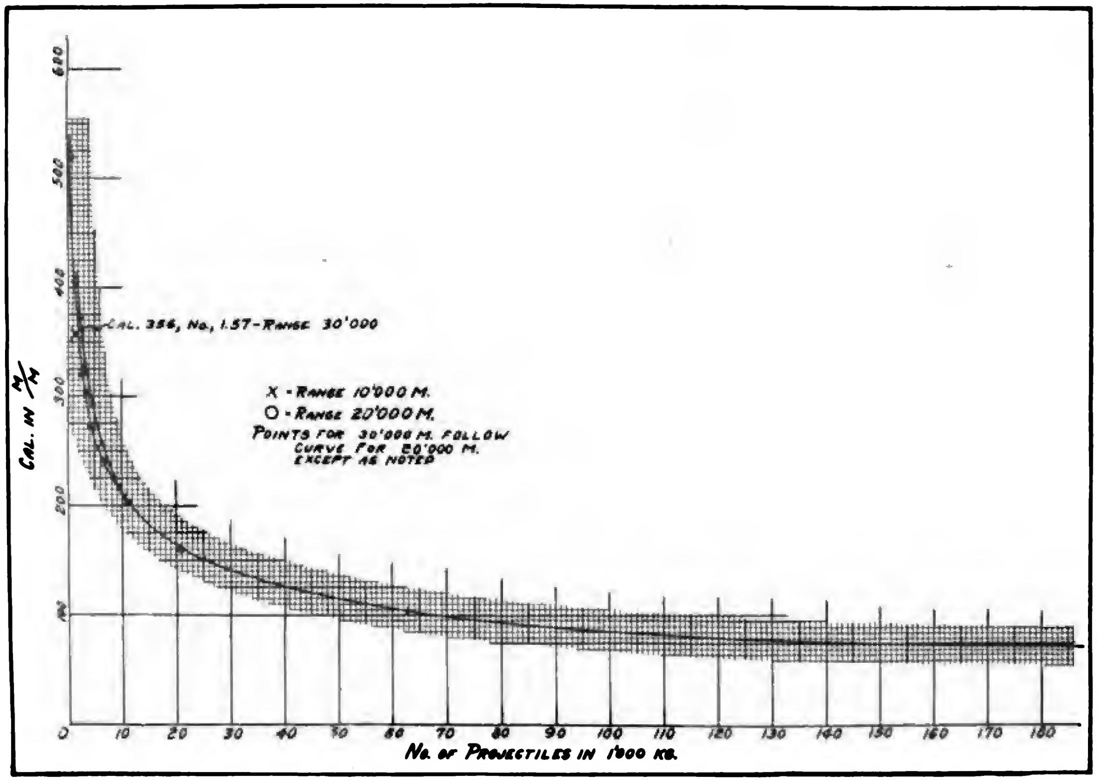
(*b*) At 20,000 meters, the same tendency is evident but to a somewhat smaller degree. The theoretical curves indicate about 150-millimeter caliber is most economical.

(*c*) At 30,000 meters, the tendency has disappeared so far as the points from actual guns indicate, and the curve derived from previous curves indicates only a very small advantage in favor of the smaller calibers. The theoretical curve also shows little difference, but indicates maximum efficiency around 300 millimeters.

749. For the ranges and calibers considered for powerful railway artillery the above would indicate that there is a most efficient caliber from the standpoint of gun wear for each range. At the shorter ranges (20 kilometers) the smaller guns are most economical, but at the longer range (30 kilometers) economy does not vary greatly with caliber and therefore does not determine it. Very long guns of small caliber would seem to have about the same economy as shorter and more normal guns of larger caliber carrying to the same maximum range.

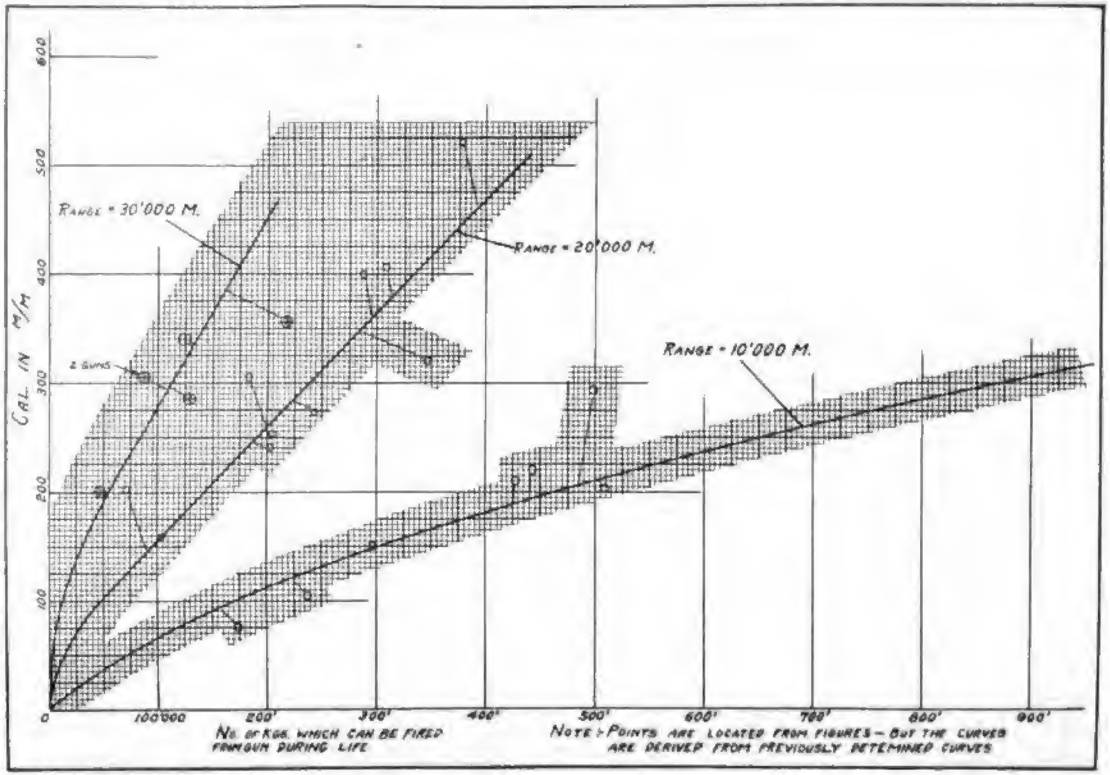
750. In order, possibly, to make clearer the steps by which the preceding curves were derived, the table below is given of the various values computed for the 20,000-meter curve, from a theoretical standpoint.

PLATE 496



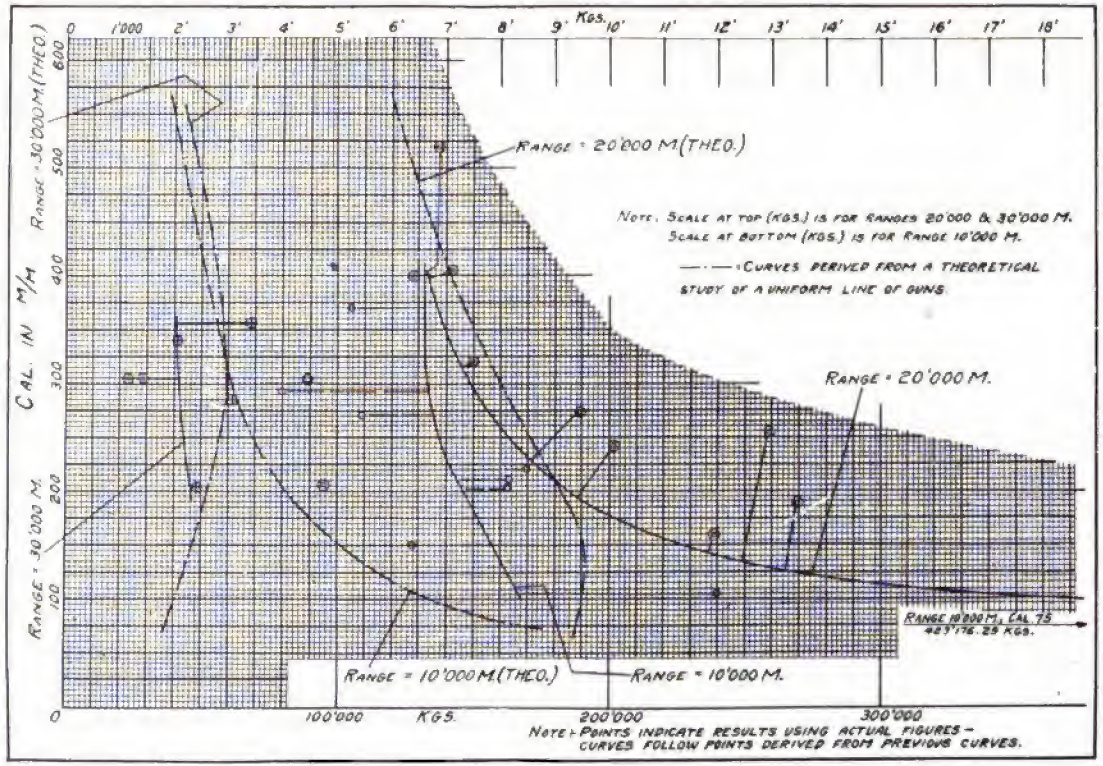
RELATION OF CALIBER TO NUMBER OF PROJECTILES IN 1,000 KILOGRAMS.

PLATE 497



RELATION OF CALIBER TO WEIGHT OF PROJECTILES PER LIFE OF GUN.

PLATE 498



RELATION OF CALIBER TO WEIGHT OF PROJECTILES PER 1,000 KILOGRAMS OF WEAR OF GUN.

Calculations for 20,000 meter range.

Cal. in inches.	Weight projectile, lbs.	Velocity, meters per sec.	Velocity, foot p. s.	Travel projectile, in.	Weight gun, lbs.	Life gun, rounds.	Kgs. projectile delivered during life.	Kgs. projectile delivered per 1,000 kgs. gun.
1	2	3	4	5	6	7	8	9
3	15	1,145	3,755	235	4,239	2,668	18,153	9,460
6	108	770	2,525	191	13,752	1,210	59,275	9,502
10	438	662	2,170	206	41,200	762	151,387	8,100
14	1,200	592	1,942	231	90,552	595	323,853	7,800
21	3,330	558	1,830	253	223,146	413	623,816	6,163

Column 1 is assumed to give a good point distribution. Column 2 is assumed from standard projectiles. Column 3 is taken from ballistic curves prepared by Capt. Kent. Column 4 is merely a translation of column 3 to English units.

751. Column 5 is found by assuming that the same maximum pressure, 38,000 pounds per square inch, and the same type of expansion, giving the same average pressure, will be used on all guns. A consideration of the mechanics of the problems will show that, under these circumstances, the travel is equal to

$$\frac{\text{Constant} \times \text{weight of projectile} \times \text{velocity}^2}{\text{caliber}^2}$$

The value of the constant is found from a study of existing guns using the maximum pressure in question and the travel is computed from the formula and recorded as shown.

752. Column 6: It is assumed that the weight of any of a line of similar guns will vary as the travel of the projectile multiplied by the square of the caliber. A constant derived from practice is used to get the actual weight in each case.

753. Column 7: The life of the gun is computed in each case from Jones's formula, elsewhere mentioned. In this case, however, a correction has been applied, based on recorded lives of French guns, so that the tendency is to lengthen the life on large calibers and shorten it on small as compared with the values given by Jones's formula. It is thought these revised figures are more nearly correct than those gotten directly from the formula.

754. Column 8 is the product of columns 2 and 7 and the factor for converting pounds to kilograms.

755. Column 9 is column 8 divided by the weight of the gun in thousands of kilograms (derived from column 6). This figure is a direct measure of the efficiency of the gun in delivering projectiles to the range in question.

APPENDIX III.

A REPORT ON THE GERMAN DEFENSES ON THE COAST OF BELGIUM (44).

PURPOSES OF INVESTIGATION AND SOURCES OF INFORMATION.

756. The investigation on which the following report is made was made primarily for the purpose of determining whether the Germans had followed fixed policies in the designs of the various mechanisms of their heavy gun carriages. With ordnance designers, there have been a number of questions on which there has been a sharp difference of opinion. Some believe that the cradles of heavy guns should be heavily braced by ribs, while others feel that there is no reason why they should not be simple smooth cylinders. Some designers are in favor of a front pintle type of carriage with simple friction bearings, or at best, roller bearings with racers of small diameter and more or less crude wheels or large rollers at the rear of the carriage on which it may be traversed. Others believe in a central pintle type of carriage with large roller paths. It is seen at once that there is a vast difference in the difficulties involved in the manufacture of carriages designed under these different principles. Cradles with heavy ribs on the outside are difficult to cast, and do not lend themselves to rapid manufacture. If smooth cylinders will answer just as well, it does not seem wise to hamper the manufacturer with the other design. Front pintle carriages are in general easier to manufacture than the center pintle type, hence unless there is something very vital to be gained in the central pintle type of carriage with its large and difficult to manufacture roller paths, it would seem that the first design should have preference.

757. In this investigation, the methods of reducing the friction of the trunnions, the designs of the elevating and traversing mechanisms, the ammunition supply system, as well as the design of the guns, were studied.

758. A report has been made on these same coast defenses from the standpoint of the problems of the coast artilleryman by Majors Armstrong and Norton. This report is dated December, 1918, and was published in the Artillery Journal in three parts, the last appearing in August, 1919.

759. Information contained herein was secured through study of reports in the offices of Gen. Arnoulde in Brussels, through conversation with Gen. Arnoulde, through inspection of all of the guns and carriages discussed, from discussion with French officers who have inspected the same material, and from the "Renseignements de l'Artillerie" of January and February, 1919.

760. The writer wishes to acknowledge his indebtedness to Lieut. Gen. Arnoulde, Chief of Artillery of the Belgian Army, for the courtesy extended by him for this inspection. Acknowledgment is made likewise of the excellent service of Sergt. J. P. Ferris, who assisted on this inspection.

HISTORY OF THE INSTALLATION.

761. The coast of Belgium was occupied by the Germans during the month of October, 1914. They occupied Ostend on October 15. It is probable that they at once installed some minor caliber guns for its defense against landing parties, but the evidence available indicates that the major caliber guns described in this report were installed during the years of 1916 and 1917, in preparation for and support of their major submarine campaign.

762. When the writer was with the British Fourth Army at Ypres in February, 1918, he was told by the British ordnance officers of that army that they had received very authentic reports to the effect that the Germans had been rapidly dismantling their second navy and were mounting the guns on railway carriages for both coast defense and land service. The 28-centimeter guns on railway mounts that were operated in the Batteries Preussen, Hanover, and one other battery not indicated on the map, were probably some of the guns removed from the second navy. The emplacements for these railway mounts did not make their appearance in the air photographs until the year 1918.

763. It is likely that the 38-centimeter gun, Battery Pommern, near Leugenboom, was placed primarily for the purpose of bombarding Dunkirk and Ypres. Both of these places were heavily shelled by a gun of this caliber during the years 1916 and 1917. Battery Goeben, at Zeebrugge, was made up of four complete turrets. In this battery the original turret equipment was complete even to the inclusion of the ammunition hoists, electrical traversing mechanism, etc.

764. During the spring of 1918, April 23, an attempt was made to block the harbors of Zeebrugge and Ostend. The mole at Zeebrugge was pierced and the boat, *Vindictive*, loaded with concrete, was placed across the entrance of the Ostend harbor. The boats engaged in these undertakings received terrific punishment, but apparently accomplished their mission. It seems probable that had the Allies cared to make the sacrifice, it would have been possible to force either

harbor, although it is not very likely that they could have retained possession of them for any great length of time. At the time of the inspection of these defenses, the writer observed the *Vindictive* still at the entrance to the Ostend harbor. It had been raised and moved to a position as close as possible to and parallel with the north side of the entrance.

765. It is significant to note that when it became necessary for the Germans to evacuate this area in August, September, and October, 1918, the only artillery that they were able to get out was the railway artillery. From the inhabitants of Ostend it was learned that all of the batteries in that vicinity had been operated quite continuously against the allied land forces for some days before the evacuation.

766. Just before the area was evacuated all the guns were destroyed with the exception of the 38-centimeter gun at Leugenboom. One method seems to have been employed on all of the guns for their destruction. In most cases they removed the rotating band from one projectile and rammed it up into the bore of the gun. A second projectile was then rammed in and the gun fired. When the rear projectile struck the forward projectile it exploded, and in every case except in the Battery Pommern, as noted above, the breech of the gun was completely blown off and in most cases the carriage practically wrecked. In some cases the forward projectile likewise exploded, swelling or tearing off the muzzle of the gun; in other cases it was simply projected a short distance out of the gun. The guns and carriages after being wrecked were practically valueless, and no attempt was made to keep them in condition.

GEOGRAPHICAL PLAN OF THE DEFENSE, SCOPE OF SERVICE, ETC.

767. The distribution of the guns of various calibers along the entire Belgian coast is shown on plate 499. Plate 500 shows somewhat better the distribution of the batteries about Ostend.

768. It is improbable that the Germans installed any considerable number of guns along this coast until it was definitely decided to inaugurate their major submarine campaign. It was vital that they have a convenient base for these submarines as close as possible to their theater of operations. The harbors at Zeebrugge and Ostend are neither very large, but both are quite ample for submarines, and both are connected by large canals with Bruges, where the submarines could be maintained. The fortifications, hence, centered about two ports, Ostend and Zeebrugge, with the battery Pommern some distance out of Ostend and placed primarily for land service. It will be noted, plate 500, that the smaller guns were all installed upon the top of the dune that parallels the coast, while the heavy guns were all placed a kilometer or more back of the dune. Except for the dune, the land along the coast is quite level—so much so, in

PLATE 490

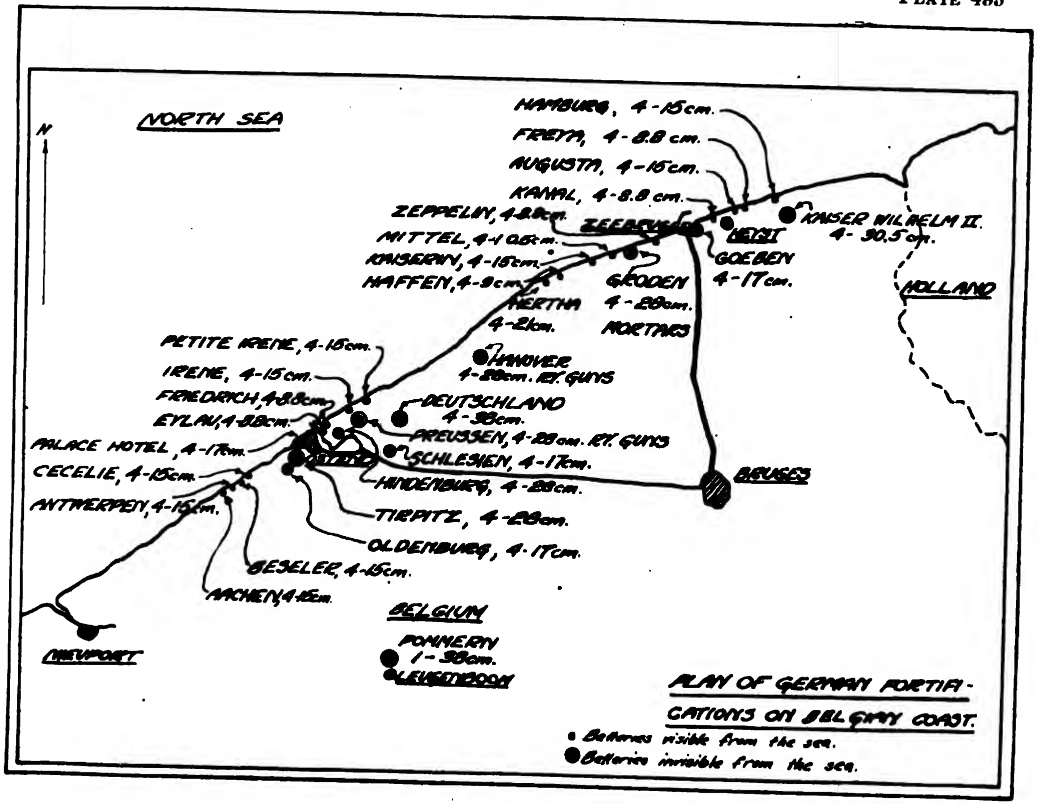
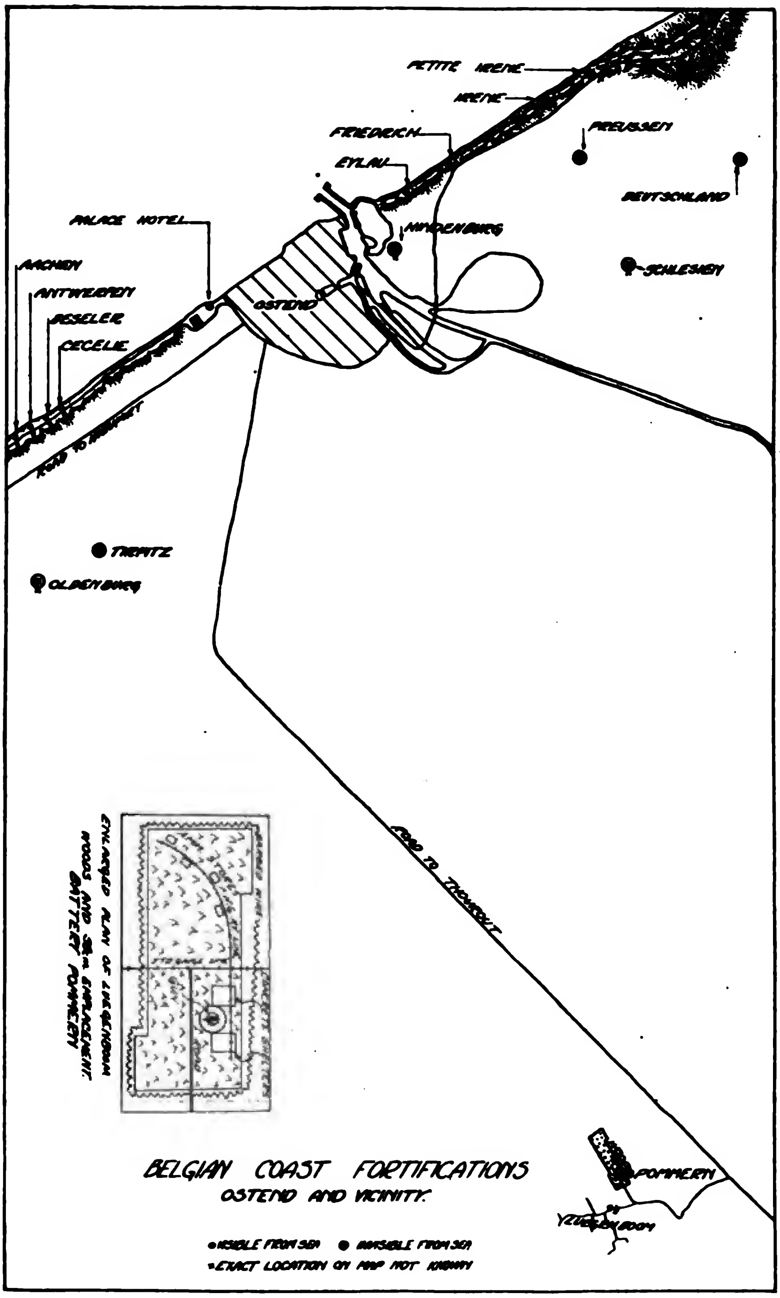

NORTH SEA
N
HAMBURG, 4-15cm.
FREYA, 4-8.8 cm.
AUGUSTA, 4-15cm.
KANAL, 4-8.8 cm.
ZEPPELIN, 4-8.8cm.
MITTEL, 4-10.5cm.
KAISERIN, 4-15cm.
HAFFEN, 4-9cm.
HERTHA 4-21cm.
ZEEBRUGGE
HEYST
KAISER WILHELM II. 4-30.5cm.
GOEBEN 4-17cm.
GRODEN 4-28cm. MORTARS
HOLLAND
HANOVER 4-28cm. RY. GUNS
PETITE IRENE, 4-15cm.
IRENE, 4-15cm.
FRIEDRICH, 4-8.8cm.
EYLAU, 4-8.8cm.
PALACE HOTEL, 4-17cm.
CECELIE, 4-15cm.
ANTWERPEN, 4-15cm.
DEUTSCHLAND 4-38cm.
PREUSSEN, 4-28cm. RY. GUNS
SCHLESIEN, 4-17cm.
HINDENBURG, 4-28cm.
TIRPITZ, 4-28cm.
OLDENBURG, 4-17cm.
BESELER, 4-15cm.
AACHEN, 4-15cm.
BRUGES
NIEUPORT
BELGIUM
POMMERN 1-38cm.
LEUGENBOOM
PLAN OF GERMAN FORTIFICATIONS ON BELGIAN COAST.
• Batteries visible from the sea.
● Batteries invisible from the sea.

PLATE 500


PETITE IRENE
IRENE
FRIEDRICH
EYLAU
PREUSSEN
DEUTSCHLAND
PALACE HOTEL
HINDENBURG
AACHEN
ANTWERPEN
BESELER
CECELIE
SCHLESIEN
OSTEND
TIRPITZ
OLDENBURG
POMMERN
BELGIAN COAST FORTIFICATIONS
OSTEND AND VICINITY.
• VISIBLE FROM SEA ● INVISIBLE FROM SEA
* EXACT LOCATION ON MAP NOT KNOWN

fact, that it is inclined to be swampy unless well drained. The guns on the dunes ranged from 8.8 to 17 centimeters, the 8.8 centimeter guns being for service against aircraft. For the heavy batteries located behind the dunes, there were heavily constructed concrete observation stations in the dunes. The stations for the batteries centered about Ostend were located one in front of the Royal Palace Hotel (near the Palace Hotel Battery) and the other in the dune near the Battery "Petite Irene."

769. All of the batteries shown on plate 499 by solid dots were located on top of the dunes and were visible from the sea. Those batteries indicated by solid dots inclosed in rings were behind the dunes and had to depend upon the stations located in the dunes for their observation. The Palace Hotel Battery of 17-centimeter guns was installed on the broad promenade just in front of the Royal Palace Hotel. This battery was particularly conspicuous. Battery Tirpitz just south of the city of Ostend was located in very swampy land, and it is understood that a great number of piles had to be driven to render the concrete emplacement stable. Considerable attention was paid to the drainage of the region around this battery and Battery Oldenburg. All of the other inland batteries were installed on comparatively dry and solid ground. The Battery Pommern, southeast of Ostend, was located on the eastern edge of a small wood known as the Bois de Leugenboom. There is no evidence that this battery was ever used against any except land targets.

770. Damage from Shell Fire and Bombs.—In spite of the fact that a majority of the batteries were located on top of the dunes and in plain sight of the sea, there is no evidence that any of them were damaged by shell fire. It is probable that no firing was done against the Palace Hotel Battery because of the damage that would be done the large buildings roundabout. It is understood on good authority that the allied ships paid constant attention to both those batteries installed on the dunes, as well as those located behind the dunes. As early as 1916 the exact locations of practically every battery behind the dunes were determined from airplanes. Some of the pictures taken of some of these batteries are shown on plates 510, 518, and 528. Other photographs are available of the remaining inland batteries. It is understood that the monitors came in within a few kilometers of the coast at night, camouflaging their gunfire by blinding flares. It is reported that on practically all occasions when the ships shelled the coast fortifications during the day heavy smoke screens were at once set up by the Germans which evidently afforded effective protection. Just back of the Battery Irene, between the dune and road, the writer found a large number of steel pots or cylinders 18 inches in diameter by 24 inches in height, which had been used by the Germans in setting up their smoke screens.

The writer saw many of the holes made by airplane bombs and shown on plate 529, but could not find any single case in which either the inland batteries or the batteries in the dunes had been struck by shell firing from sea or by bombs dropped by airplanes.

771. It is understood that the British monitors controlled their fire by the scheme of triangulation. Knowing that the Germans would at once set up a smoke screen between the batteries fired upon and the monitors firing, they were in the habit of placing one boat of inconspicuous construction a great distance off to serve as observer. This observing boat was so located as to be able to see behind the smoke screen. For firing on the heavier batteries, behind the dunes, it was of course necessary to operate by indirect fire.

772. Scope of Service.—The range and scope of service of the various batteries is shown on plate 501. All of the guns, except the 38-centimeter gun Pommern at Leugenboom, were capable of being traversed 360 degrees. The range of 55 kilometers reported for the Deutschland seems extreme. Various reports conflict in this respect, some crediting the batteries with a range of 42 kilometers, some with a range of 47 kilometers, and the last report, given in the Bulletin Renseignements de l'Artillerie of January and February, 1919, with 55 kilometers. The ranges given on plate 501 are in accordance with the report in the bulletin just mentioned.

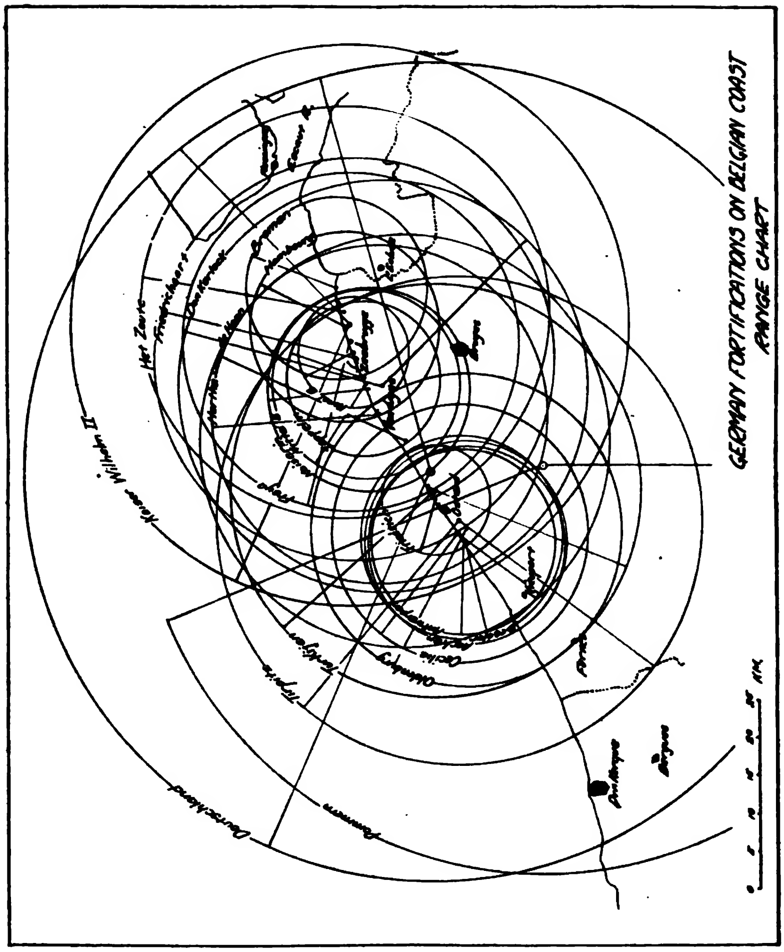
DISCUSSION OF THE MECHANISMS.

38-CENTIMETER GUN BATTERY POMMERN (45).

773. Gun.—This battery, plate 502, consisted of but one gun, model 1914, Krupp, No. 15 L. Its weight is 77,530 kilograms, over-all length 17.13 meters, and length from breech block to the muzzle, 16.13 meters, giving it an effective length of 42 calibers. It seems to be rated in some reports as a 45-caliber gun. This rating is evidently based on its over-all length. There are 100 grooves, and the twist of the rifling is to the right 1 centimeter in 10. The diameter of the powder chamber is 42.5 centimeters, and the outside diameter of the breech 1 meter. The breech is of the usual Krupp sliding wedge type and its mechanism is identical with that on the 38 centimeter gun on the railway mount. The design of the gun is likewise identical with that of the gun on the railway mount, and with the 38-centimeter guns of the battery Deutschland, plate 506. On this plate it will be observed that the breech section has been blown away. The scheme of attaching the breech section by the interrupted ring method is well shown. As in the case of the railway mount, the recoil lug has a bearing at the bottom on the two sides of the recuperator cylinder to prevent rotation of the gun.

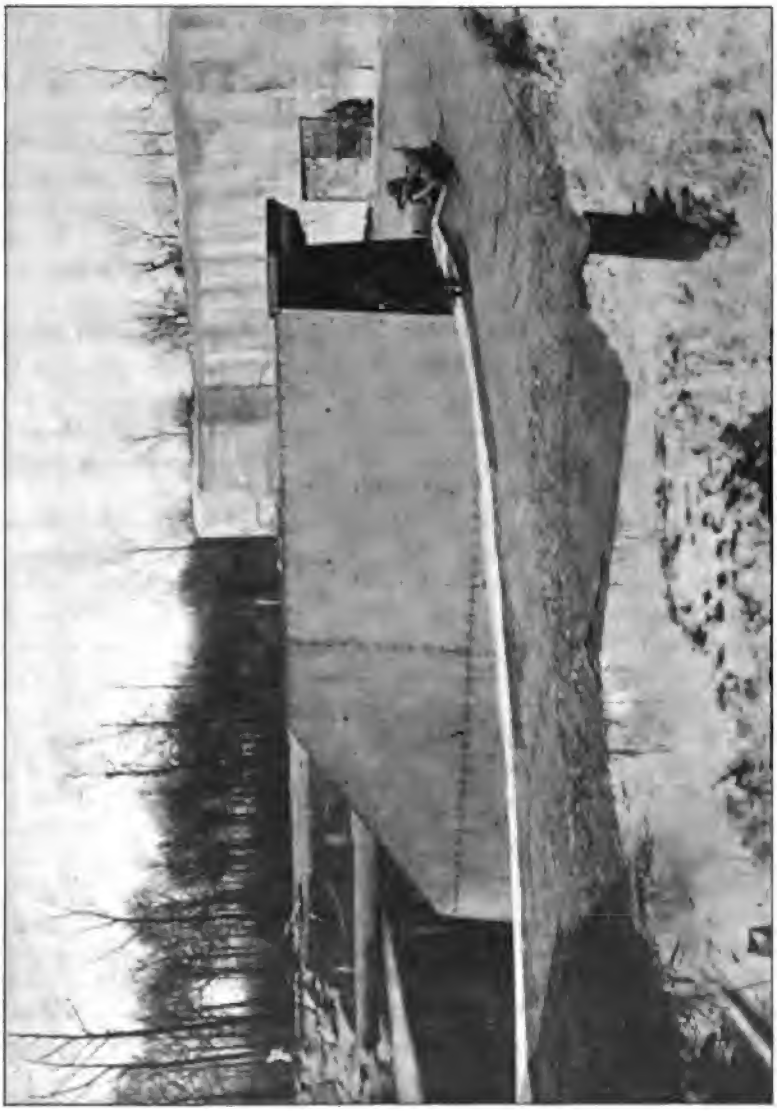
774. Cradle.—The cradle is a cylinder of simple design, having ribs at long intervals and a depth of only about 3 centimeters. The

Plate 501



GERMAN FORTIFICATIONS ON BELGIAN COAST RANGE CHART

PLATE 502



38-CM. GUN, GERMAN BATTERY POMMERN.

walls of the cylinder have a minimum thickness of 10 centimeters and a maximum thickness of 13 centimeters over the ribs. The diameter of the main trunnion, plate 503, is 46 centimeters and the length 33.5 centimeters; the diameter of the small trunnion 20 and the length 19 centimeters. It will be observed that the antifriction mechanism is of the rolling wedge type. This cradle was provided with a counterweight identical with that shown on plate 506, and its front is so designed as to close the opening in the turret. Its total length is 3 meters, and it is provided with brackets for the recoil and recuperator cylinders on the bottom as shown in plate 403. The cradle is lined with a bronze liner, approximately 6 millimeters thick and 1 meter in length both at the front and rear. A portion of this liner may be seen on plate 506.

775. RECOIL MECHANISM.—For the description of the recoil mechanism, see "Recoil mechanism" of the 38-centimeter gun on the railway mount. The two recoil cylinders, plate 403, are carried in brackets on either side and the filling plugs are on the ends of the buffers. The recuperator cylinder is carried in the center in similar brackets and likewise has a filling plug on its forward end. As mentioned before, its rear end, which is planed on both sides, serves as a guide for the breech lug to prevent rotation of the gun.

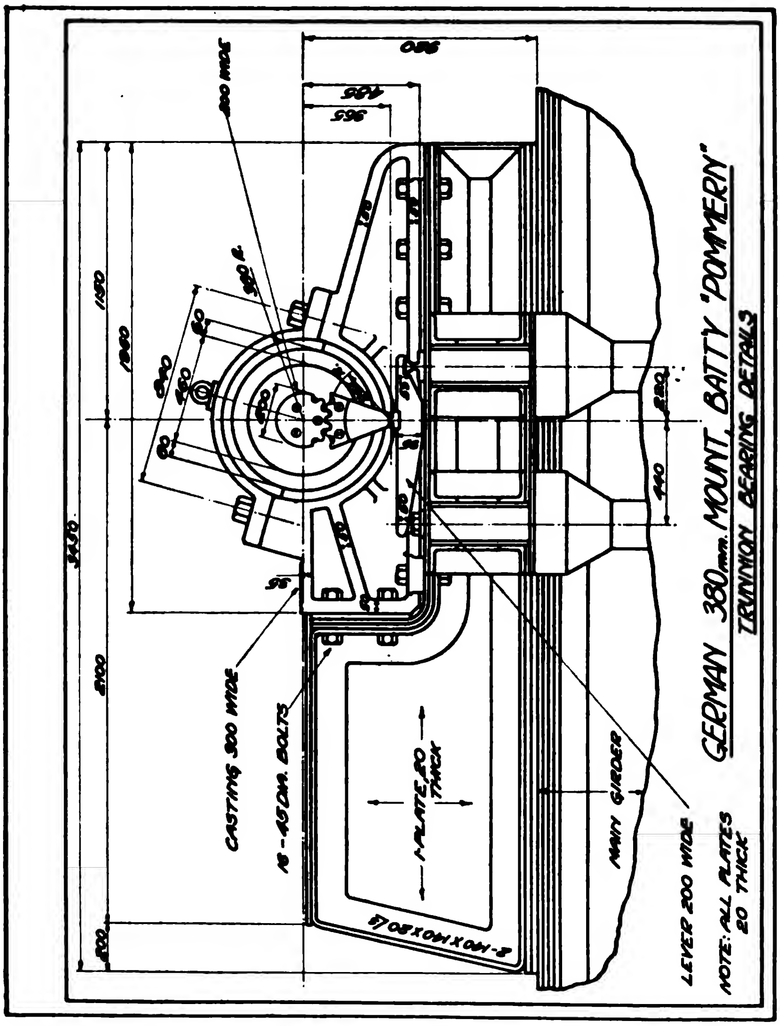
776. ELEVATING MECHANISM.—See the same for the 38-centimeter guns of the Battery Deutschland. The only difference between the two is that in this battery there was no provision for hand operation. The report found in Gen. Arnoulde's office stated that this gun had been originally provided for hand operation only, but that within the last year it had been equipped with motors for electrical operation. The maximum elevation obtainable is 45 degrees.

777. TRAVERSING MECHANISM.—See description of the traversing mechanism of the Battery Deutschland. There is provision for both hand and power operation of this mechanism. The wheel for hand operation, however, is located on the left of the carriage very close to and on a level with the traversing rack. It is 1 meter in diameter. The maximum traverse provided for is about 157 degrees. The center line of this field of fire passes approximately through Dunkirk.

778. CARRIAGE.—See detailed description of the carriage for the 38-centimeter guns of the Battery Deutschland. The only difference between these carriages is in the armor provided on the guns of the Battery Pommern. This will be described later under the heading of "Protection."

779. EMPLACEMENT.—The emplacement for this carriage is of exceedingly massive concrete construction. The diameter of the central pit or well in which the carriage is placed is approximately 22.439 meters. The form of the pit is not a complete circle, but is so shaped as to allow the carriage to traverse 157 degrees. The

PLATE 508


GERMAN 380mm. MOUNT, BATTY "POMMERN"
TRUNNION BEARING DETAILS
CASTING 300 WIDE
16-45 DIA. BOLTS
PLATE 20 THICK
MAIN GIRDER
LEVER 200 WIDE
NOTE: ALL PLATES 20 THICK
300 WIDE

depth to the level of the traversing rack is 3 meters and the additional depth to the floor on which the center pintle rests 1.5 meters, making a total depth of 4.5 meters. On either side are practically identical concrete structures for the housing of ammunition and personnel. The structure on the right is for projectiles and tools. Between these two structures at the front, plate 502, there is a concrete parapet 2 meters high and 3 meters thick. The earth slopes gradually away from the top of the parapet at the front, dropping about to the level of the main floor of the emplacement on which men are seen standing. The thickness of the roof of the structures on the right and left is 3 meters, the total height above the floor being 5.5 meters.

780. AMMUNITION AND AMMUNITION SUPPLY SYSTEM.—As just noted under the heading of "Emplacement" the projectiles were stored in the concrete storehouse on the right and the powder in the storehouse on the left. Three weights of projectiles were used, one of which is shown on plate 504. This projectile has a false ogive. The ammunition was supplied entirely by hand, the shot truck being of the design shown on plate 505. The arrangement of the storehouse is in general similar to that for the 305-millimeter gun of the Battery Kaiser Wilhelm II, plate 517, the projectiles being piled two high. Gen. Arnoulde's report states that the projectiles were rammed by 12 men and that the rate of fire was one shot in five minutes with electrical operation of the elevating mechanism, and one shot in 10 minutes with hand operation of the elevating mechanism. Gen. Arnoulde's report further states that according to reports of people living at Leugenboom, the personnel originally provided for operation of the mount when it was operated by hand was 1 captain, 2 lieutenants, 10 noncommissioned officers, and 160 men. After provision was made for electrical operation of the various mechanisms, the personnel was reduced to 1 captain, 2 lieutenants, 5 or 6 noncommissioned officers, and 70 men.

781. The shells fired by the 38-centimeter gun are:

Name.	Weight.	Fuse.	Range.
H. E. 38 cm. Sp. Gr. L/4.1 Bdz., with base fuse.	750 kg.	Sp. Grm. K.	42 km.
H. E. 38 cm. Sp. Gr. L/3.6 m. Bdz. (mHaube), with false ogive and base fuse.	695 kg. (600 without false ogive).	Sp. Grm. K.	44 km.
H. E. 38 cm. Sp. Gr. L/4 Bdz. A. Kz (mHaube), with double fuse at head and base false ogive.	342 kg. (without false ogive).	Sp. Grm. K.	48 km.

The charges are three in number:

(*a*) Hutzenkartasch, cartridge containing 87 kg.

(*b*) Vorkartasche, charge containing 96 kg.

(*c*) Vorkartasche, charge containing 118 kg.

PLATE 504

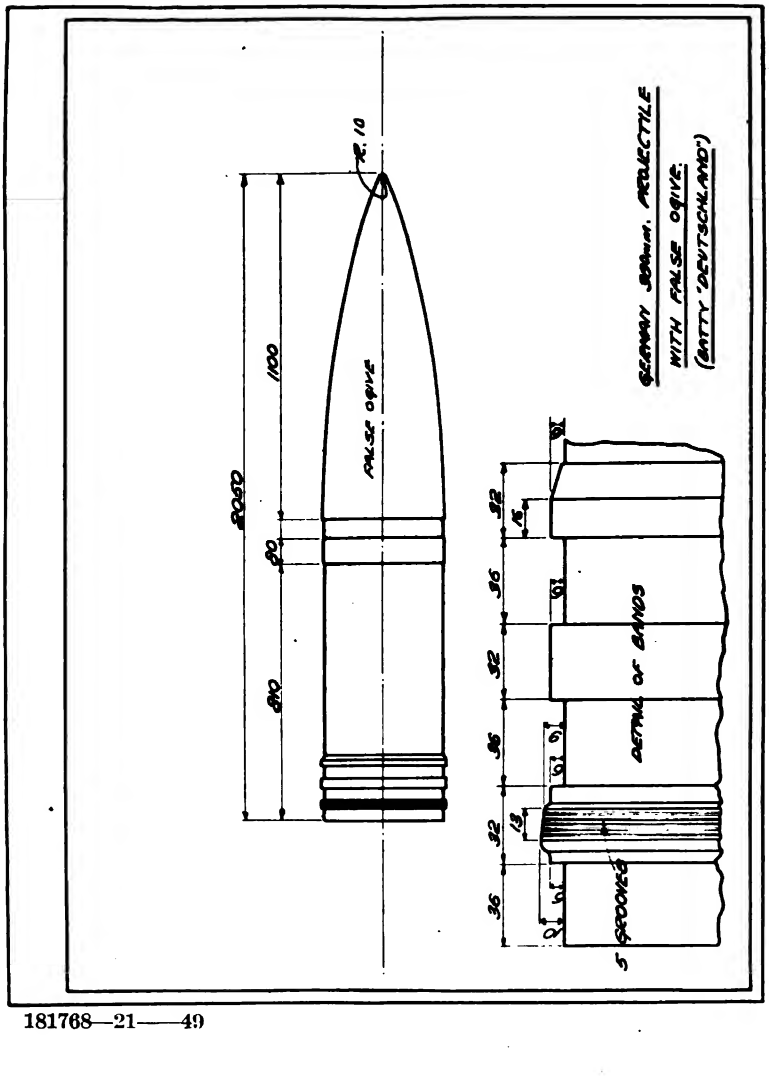
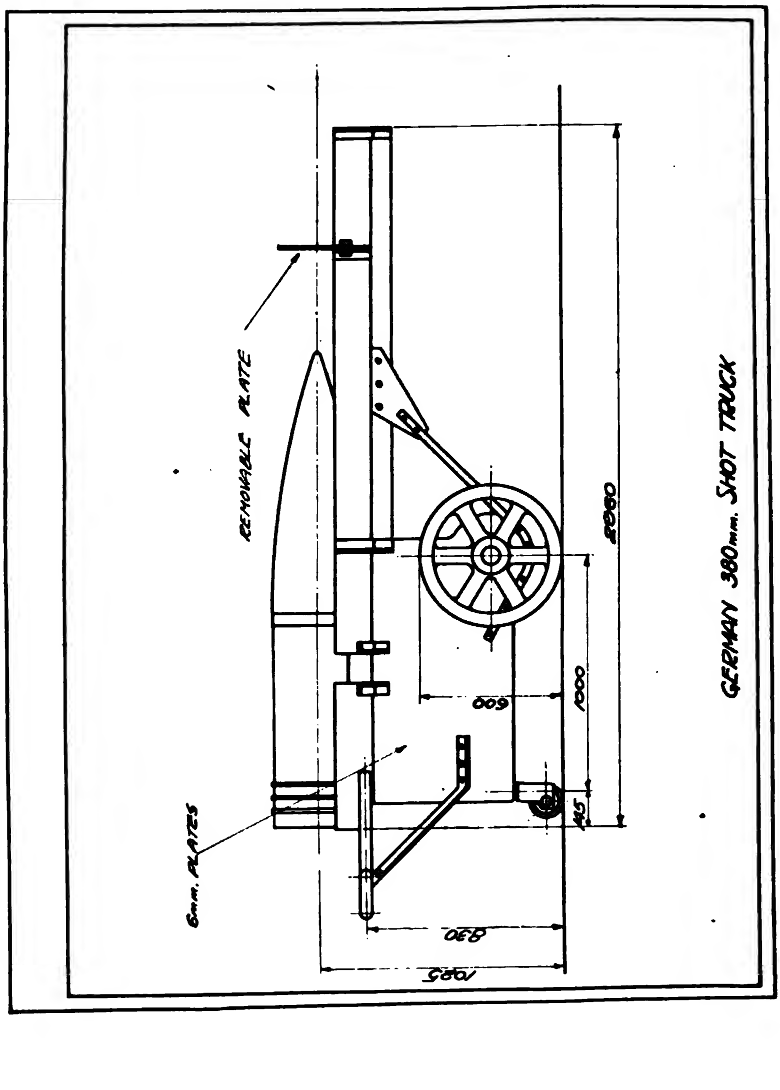

WITH FALSE OGIVE.
(BATTY 'DEUTSCHLAND')
FALSE OGIVE
DETAIL OF BANDS
5 GROOVES

Plate 505



GERMAN 380mm. SHOT TRUCK

It seems then that the gun can fire with two charges; that is:

(1) 87 kg. plus 118 kg. = 205 kg.

(2) 87 kg. plus 118 kg. plus 96 kg. = 301 kg.

782. PROTECTION.—To protect the personnel operating this gun against aircraft bombs and aircraft machine-gun fire, the carriage was covered with 6-centimeter flat armor. This plating extended to within a few centimeters of the floor of the pit. The hole in the front through which the guns extend is sealed by the small shield on the front of the cradle.

783. DISCUSSION. On plate 502 it will be observed that the parapet just in front of the gun has been blown away in the center. There is evidence to the effect that the Germans used their characteristic method in attempting to destroy this gun, but that in this case neither projectile detonated until they struck the parapet in front. Neither projectile could be found, hence it is assumed that both detonated. The gun was damaged only to a slight extent at the muzzle, where some fragments of the projectiles were blown back into the bore, scoring it deeply.

38-CENTIMETER GUNS, BATTERY DEUTSCHLAND.

784. GUN.—See description of the 38-centimeter gun of the Battery Pommern. The design of these four guns is identical with the design of the model 1914 Krupp gun, No. 15–L. The gun, plate 506, is a model 1916, No. 36–L. Its weight is given as 77,562 kilograms. This gun is No. 4 of the battery; No. 3 is likewise a model 1916, and numbered 35–L. Gun No. 2 is model 1916, No. 41–L, and gun No. 1 is model 1914 No. 9–L.

785. Each of these guns had been destroyed by the characteristic German method of placing one projectile in the bore of the gun and firing another projectile into it. This procedure had resulted, in this case, in the blowing off of the entire breech and in the wrecking of the carriage. There was little evidence that any of these guns had been used to any great extent. The lands and grooves were in well-nigh perfect shape; at least, it was evident that such damage as was visible had not been caused through ordinary fire. The width of the lands is 6 millimeters, and the depth of the grooves 3 millimeters. In connection with the procedure in destroying the guns, reference is made to plate 532, on which is shown one of the projectiles from which the band had been removed. This projectile was found beside gun No. 3.

786. CRADLE.—The cradle on each of these four guns is identical in design with that of the 38-centimeter gun of the Battery Pommern and of the 38-centimeter gun of the railway mount. The counterweight on the cradle of the railway mount is collapsible. The counterweights on the Battery Pommern and Battery Deutschland cradles are as shown on plate 506. The one point of difference be-

Plate 506

38-CM. GUN OF THE GERMAN BATTERY DEUTSCHLAND.

tween the cradles of three of these guns and the cradle of the gun on the Battery Pommern is in the lack of any provision for the reduction of the friction of the trunnions. On plate 506 it will be observed that there are no auxiliary trunnions and no friction reducing mechanism. There was no friction reducing mechanism on guns Nos. 2, 3, and 4, but gun No. 1 had a friction reducing mechanism identical with that of Battery Pommern, plate 503. This omission of anti-friction devices on guns Nos. 2, 3, and 4, which, by the way, are model 1916 guns, can hardly be attributed to the lack of time for the installation, since the small amount of machine work necessary in the shop might have been handled without difficulty, and the work finished in the field if desired. Apparently they preferred to rely on a surplus of man power in elevating their guns.

787. Recoil Mechanism.—The recoil mechanism is composed of two recoil cylinders and one spring pneumatic recuperator cylinder all located at the bottom of the cradle. It is identical in design with the recoil mechanisms of the Battery Pommern gun and the 38-centimeter railway mount, plate 404.

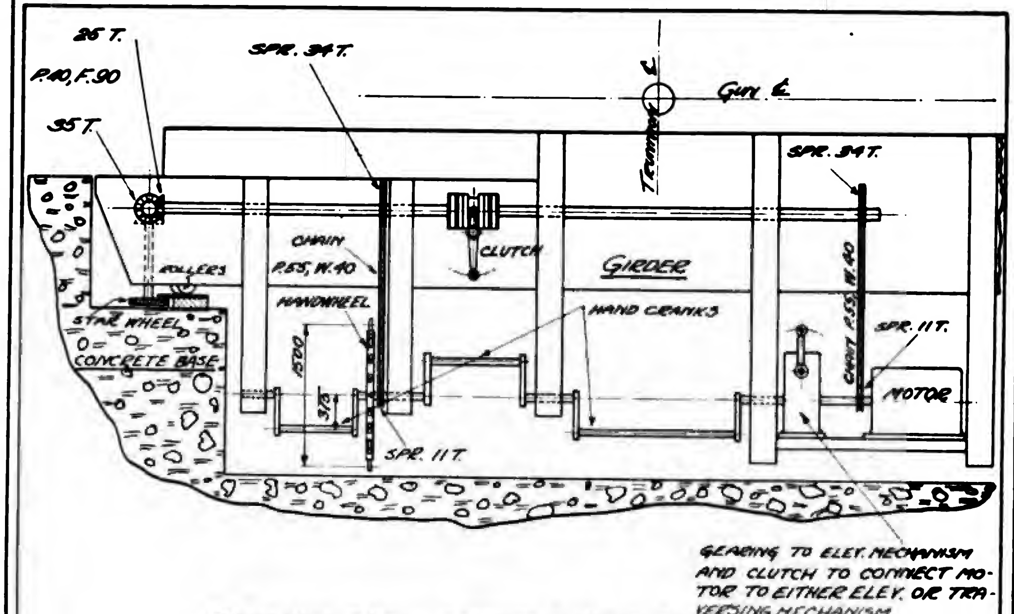
788. Elevating Mechanism.—The elevating mechanism on all of these guns, as well as on the 38-centimeter gun of the Battery Pommern, is composed of two large telescoping screws, the larger screw passing through a nut carried in the crosshead at the bottom of the cradle, plate 506. On this plate the larger of the elevating screws can be seen about in line with one of the elevating and traversing handles at the bottom of the carriage. The larger of these two screws is about 24 centimeters in diameter and the smaller about 15 centimeters. The large nut in the crosshead is driven either from the motor, or by the hand mechanism which is used likewise for the traversing mechanism.

789. The maximum elevation at which the gun is operated is not known. There were no elevating arcs remaining on any of the cradles that would indicate to what extent it could be elevated. It is assumed, however, that the maximum elevation obtainable is the same as that in the Battery Pommern gun, which is 45 degrees. On plate 506 the motor driving the elevating and traversing mechanisms is hidden by the wire camouflage which has fallen. The box just to the rear of the camouflage is the housing for the clutch connecting the elevating mechanism with either the motor or the hand drive. All of this mechanism is duplicated on the left side of the carriage.

790. Traversing Mechanism.—The various details of the traversing mechanism are shown on plates 507 and 508. Provision is made for its operation by hand as well as by motor. This hand mechanism is operated by eight men.

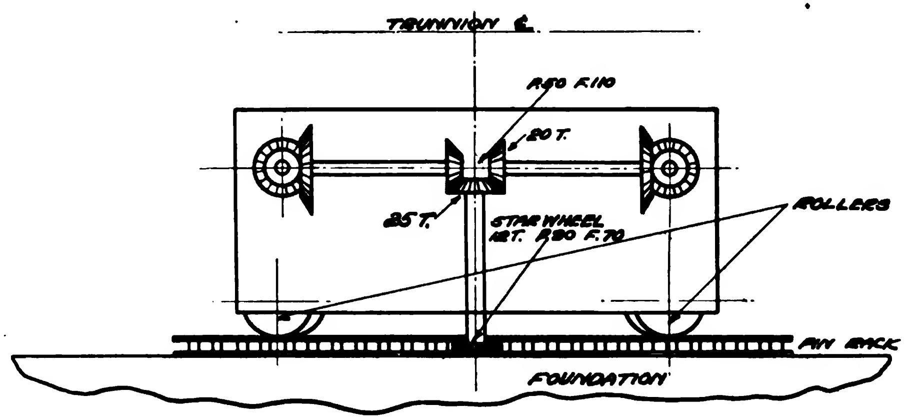
791. The rear of the carriage is supported on two heavy rollers 96 centimeters in diameter by 23 centimeters on the face, which are carried on 21-centimeter spindles. A complete circular steel bearing

PLATE 507



GERMAN 380mm. MOUNT, BATT'Y "DEUTSCHLAND"
TRAVERSING MECHANISM
ELEVATION, FIG. I.

PLATE 508



GERMAN 380mm. MOUNT, BATTY "DEUTSCHLAND"

TRAVERSING. MECHANISM

REAR ELEVATION, FIG. 2.

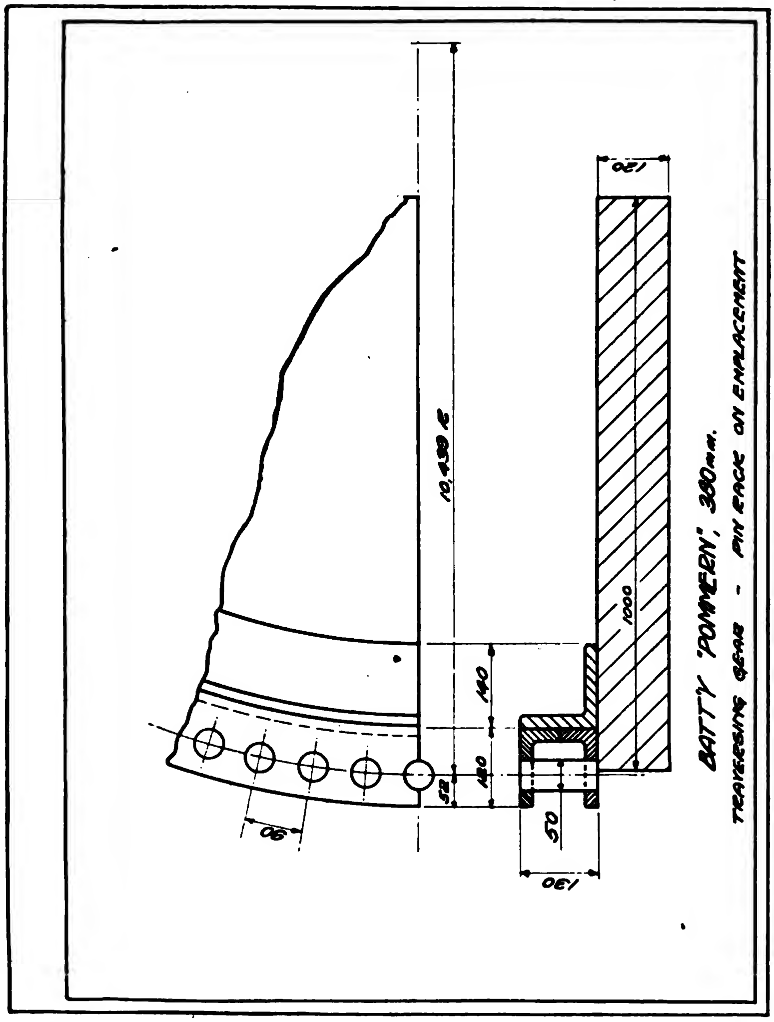
plate is bolted to the first shelf of the pit. This plate is 12 centimeters thick by 1 meter in width and to its outer edge, plate 509, is bolted a traversing arc made of 3 angles and a series of 5-centimeter steel pins. The star traversing pinion, 21 centimeters outside diameter, meshes with this rack and is driven by either the motor or the hand mechanism. The radius to the center of the traversing rack is 10.439 meters.

792. CARRIAGE.—The carriage is entirely of structural steel, plate 506. It is of the front pintle type, the front being carried on steel balls. The ball path is 2 meters in diameter and the balls 15 centimeters in diameter. It is assumed that some provision is made for direct contact between the racer and base to transmit the horizontal component of the force of recoil into the foundation. It was not possible to see the details of construction to confirm this supposition. Examination of some other carriages of similar design indicated that at least in some cases the racer was simply permitted to climb the balls when the gun was fired, no provision being made for positive contact. As noted under "Traversing mechanism," the rear of the carriage is supported on two rollers 96 centimeters in diameter. These rollers have a face of 23 centimeters and are carried on steel spindles 21 centimeters in diameter. The distance between the centers of these journals is approximately 3.3 meters. The rollers appeared to be perfectly cylindrical, with rounded edges. The construction of this carriage for one of their heaviest guns is exceedingly simple. The only heavy castings are those for the pintle, the elevating cross head, and the trunnion bearing. The only parts of the entire mechanism which obviously require fine machine work are the trunnion bearings, the heavy steel balls, and the ball paths.

793. EMPLACEMENT.—With the omission of the heavy concrete structures described under Battery Pommern for ammunition and personnel, the emplacements for the Batteries Pommern and Deutschland are nearly identical. Battery Pommern was finally fitted up for electrical operation only, and most of the mechanism for hand operations is removed. In the lower part of the Battery Deutschland pit a wood floor made up in sectors raised the floor to such an extent that the men operating the traversing and elevating mechanisms would be on the proper level. As seen in plate 506 the pit was filled with water at the time of the inspection to such an extent that these sectors had come loose and were floating. The emplacement provided for 360 degrees traverse of the carriage as against 157 degrees for the Battery Pommern.

794. AMMUNITION SUPPLY SYSTEM.—See description of the ammunition supply system for the Battery Pommern. There was no evidence of any provision of any mechanical handling of the projectiles except in the lifting of them from the floor to the storehouse and placing

PLATE 509


10,439 R
130
1000
140
180
52
50
130
90
BATTY "POMMERN", 380mm.
TRAVERSING GEAR - PIN RACK ON EMPLACEMENT

them on the shot trucks. Between guns Nos. 2 and 3 of this battery, there was found a practice shell ramming tray somewhat similar to that shown on plate 517 for the Battery Kaiser Wilhelm II. This tray was made of a steel trough about 10 feet long with an ordinary railway car buffer at the end. In the tray there was a rather blunt nosed projectile with its rotating band removed. This projectile had evidently been used for practice in ramming.

795. PROTECTION.—It is significant to note with reference to the three of the newest of these guns, that is, Nos. 2, 3, and 4, that there was absolutely no protection provided either for the gun carriage or personnel. Evidence of their scheme of camouflage can still be seen on plate 506. This camouflage was unable to hide the guns from the air photographers since photographs taken on August 9, 1916, plate 510, showed the emplacements quite plainly. In spite of this fact, there was no evidence to the effect that any of the guns or emplacements had ever been damaged by either shell fire from sea or by bombs from the air. Several holes that had been made, either by bombs or by shells, were visible in the fields in front of the guns. Gun No. 1 was protected with 6-centimeter armor in the same fashion as the gun of Battery Pommern. Gun No. 1 of this battery and the 28-centimeter gun of the Battery Pommern are identical in design throughout. Both are model 1914 guns, and it is probable that the hand elevating and traversing mechanism of the Pommern gun was identical with those of the Deutschland guns before the electrical equipment was provided.

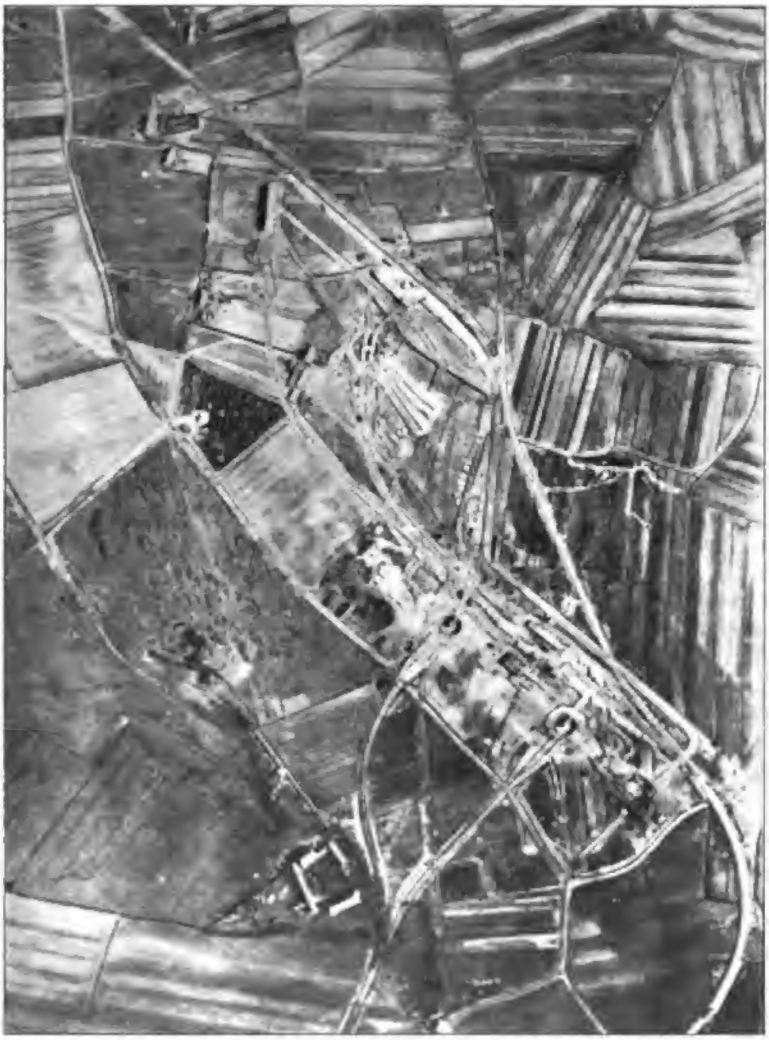
796. DISCUSSION.—Significant points with reference to this battery are that guns Nos. 2, 3, and 4 are not provided with either trunnion antifriction device or positive protection in the form of steel armor.

305-MILLIMETER GUN, BATTERY KAISER WILHELM II.

797. GUN.—With each of these four guns, plate 511, the scheme of destruction was so effective that it was impossible to find a breech after a half day's search. It is assumed that they were of a model at least as late as 1916. The Bulletin de Renseignements de l'Artillerie states that they were 50 calibers in length. One breech block was found; this was of the usual Krupp sliding wedge type. There were 88 grooves and the twist of the rifling is to the right 1 centimeter in 10 centimeters. Projectiles found in the storehouse and shown on plate 574 have two rotating bands from which it may be assumed that the pitch of the rifling is uniform.

798. CRADLE.—The cradles for all of these guns are smooth cylinders, the walls of which are 10 centimeters thick. The brackets at the bottom of the cradle provided for the recoil and recuperator cylinders, are quite similar to those shown on plate 419 of the 38-centimeter gun. The front of the cradle is provided with shield, plate 552,

PLATE 510



AIR PHOTOGRAPH OF THE GERMAN 38-CM. BATTERY DEUTSCHLAND (TAKEN AUGUST 9, 1916).

PLATE 511

305-MM. GUN OF THE GERMAN BATTERY KAISER WILHELM II.

which closes the opening in the armor; it is not improbable that these were likewise some of the guns removed from the second navy. The cradle is likewise provided with a heavy counterweight which can also be seen on plate 403. The antifriction device, plate 512, is of the rolling wedge type. It is significant that in this case the auxiliary trunnion is very little less in diameter than the main trunnion. In practically all other cases observed, the diameter of the small trunnion was approximately one-half of the diameter of the large trunnion.

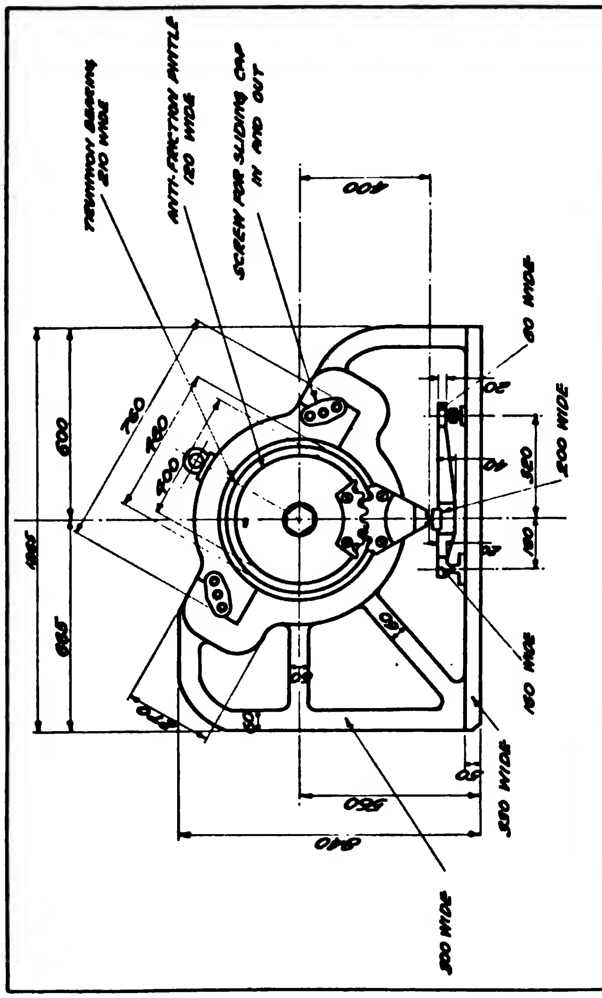
799. Recoil Mechanism.—The recoil mechanism for this gun is in general a duplicate of that shown on plate 403 for the 38-centimeter gun. The breech lug with the method of attaching the recoil pistons, and the bearing of the lug on the recuperator cylinder to prevent rotation of the gun are shown on plate 515. In contrast to the 38-centimeter gun in which the recoil pistons pass through holes in the recoil lug and the recoil lug bears on two planed sides of the recuperator cylinder, it will be observed in this case that the lug is slotted on the sides to receive the recoil pistons and the bearing on the recuperator cylinder is circular instead of flat.

800. The outside diameter of the recoil cylinder is 38 centimeters and the length is 1.68 meters. The diameter of the piston is 15 centimeters and the length of recoil 1.37 meters. These cylinders are both smooth forgings with flanges at the front bearing against the cast bracket on the cradle. There was no evidence of a counter-recoil buffer. On the front end of the cylinders, there are filling plugs similar to those found on the 38-centimeter cradles. The single recuperator cylinder is likewise a smooth forging with one large flange on its forward end. It is of the combined air-spring type and is approximately 45.6 centimeters in diameter by 4.25 meters in length. This cylinder likewise has a filling plug at the front end.

801. This is a timely opportunity to mention a fact that seems to the writer quite striking. Although the Germans follow, in general, fixed policies in their designs, their methods of application differ very widely. Apparently general specifications are given to the manufacturers who are permitted to modify them in details to suit their convenience. It does not seem probable that any designer or groups of designers would make such radical differences in the design of the details of their mechanisms as is evident on these guns and carriages. This is even more striking on their 21, 24 and 28-centimeter railway mounts.

802. Elevating Mechanism.—The elevating mechanism for these guns is in principle the same as the elevating mechanism for the 38-centimeter railway mount. The design of its details are, however, quite different, plates 513 and 514. Apparently it was operated entirely by hand. There are two two-man handles below the

PLATE 512



GERMAN 305mm. MOUNT, BATTY "KAISER WILHELM II."

TRUNNION BEARING DETAILS.

PLATE 513

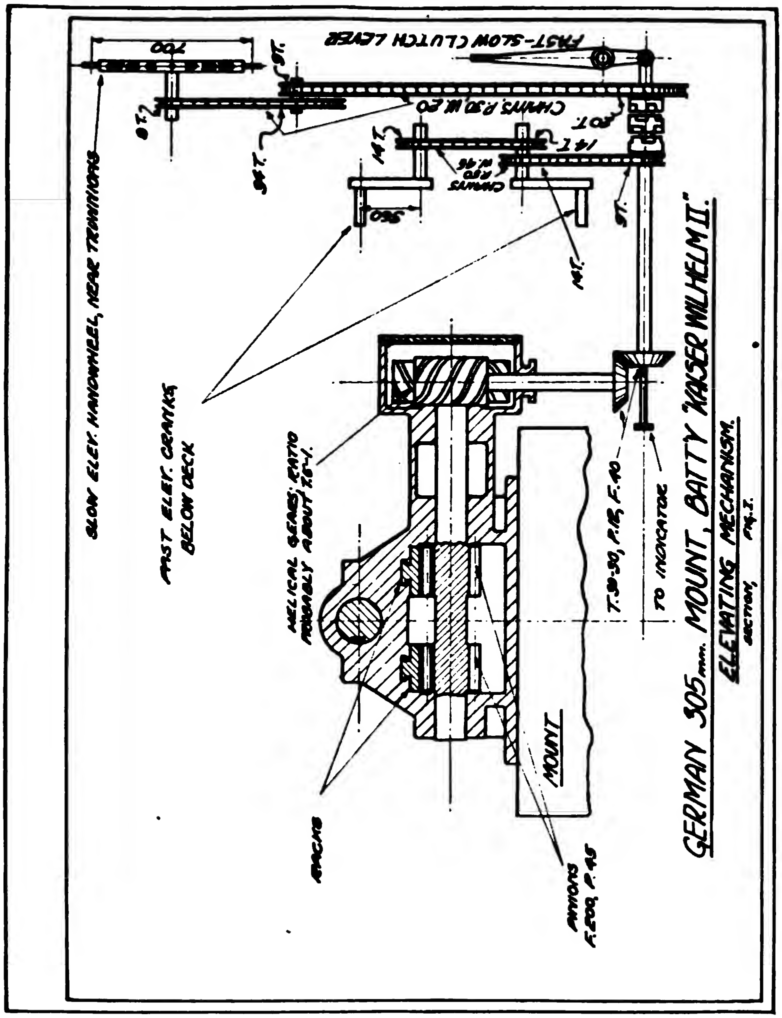
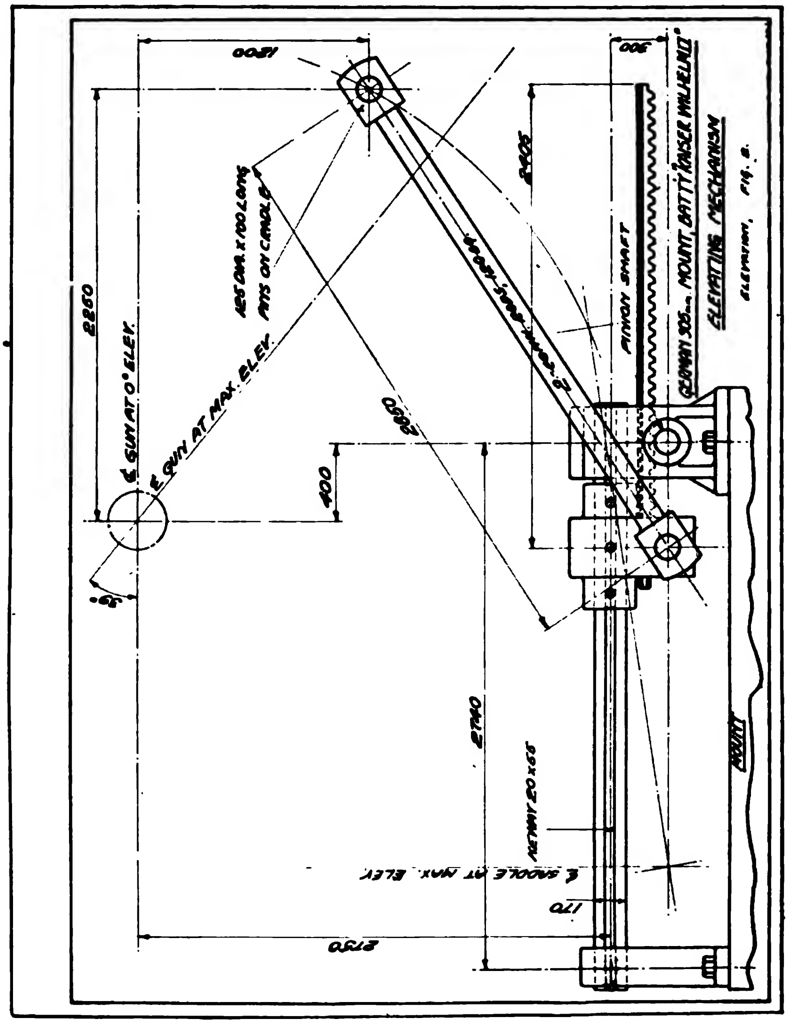

GERMANY 305 mm. MOUNT, BATTY "KAISER WILHELM II."
ELEVATING MECHANISM.
SECTION, FIG. I.
SLOW ELEV. HANDWHEEL, NEAR TRUNNIONS
FAST ELEV. CRANKS BELOW DECK
FAST-SLOW CLUTCH LEVER
HELICAL GEARS; RATIO PROBABLY ABOUT 7.5-1.
TO INDICATOR
MOUNT
RACKS
700

PLATE 514


GERMAN 305 m/m MOUNT, BATT'Y KAISER WILHELM II
ELEVATING MECHANISM
ELEVATION, FIG. 8.
PINION SHAFT
MOUNT
℄ GUN AT 0° ELEV.
℄ GUN AT MAX. ELEV.
℄ SADDLE AT MAX. ELEV.
125 DIA. x 100 LONG PINS ON CRADLE
KEYWAY 20 x 65
1200
2260
400
2850
2740
2750
170
2405
300

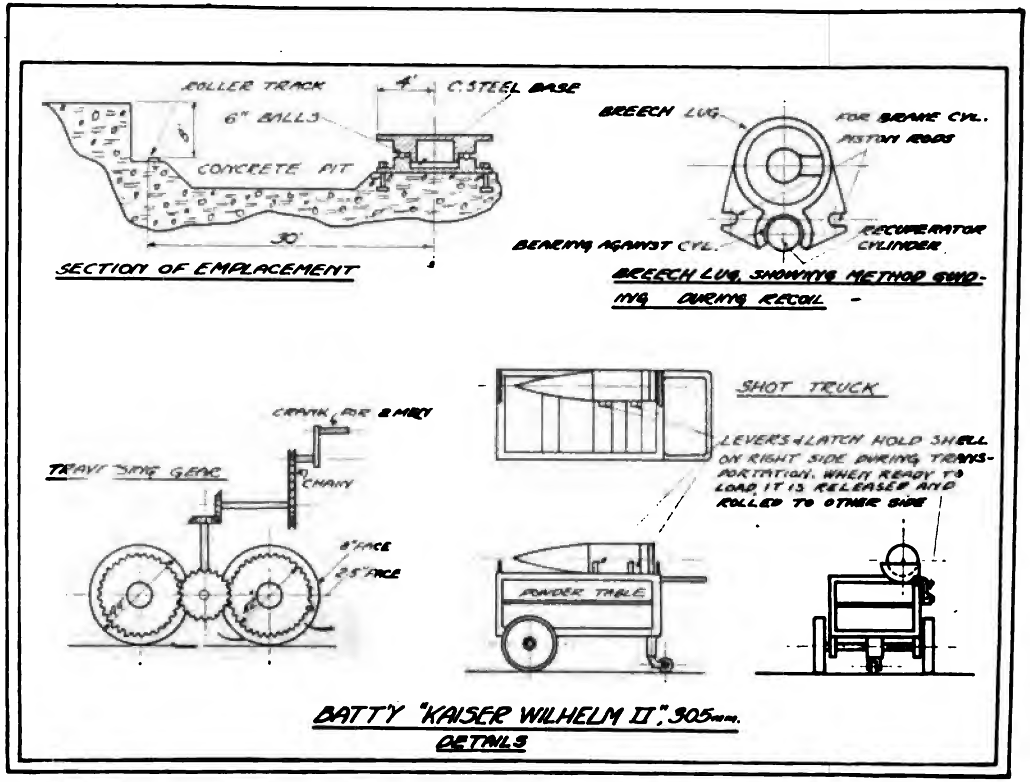
deck of the carriage for rapid elevation and above the deck a single handwheel of large diameter for final and careful setting. The clutch for shifting from the low gear to the high is located below deck. Motion is transmitted from the handwheels to the horizontal shaft at the bottom and through the bevel and helical gears to the two pinions on the main horizontal elevating shaft. The two straight racks, which in this case are horizontal, plate 513, are connected to the crosshead which slides on a single round shaft as a guide. This crosshead in turn transmits motion to the gun through the two connecting rods. The two racks have guides on the top which slide in ways in the forward support of the main horizontal guide shaft, plate 554. It was not possible to elevate the gun, and the ratio of the gearing is not known. This mechanism, together with its companion mechanism on the 38-centimeter railway mount, are quite unique among the mechanisms observed on all German artillery. The reasons for the design seen on the railway mount seem obvious, but the same reasons do not hold for this carriage. Certainly, a simpler mechanism of equal efficiency could have been provided. The maximum elevation obtainable is 45 degrees.

803. Traversing Mechanism.—The traversing mechanism, figures 1 and 2, plate 515, is operated both by hand and motor. The roller track set in the concrete emplacement is shown in figure 1. In this case, contrary to the design of the same mechanism for the Battery Pommern and Deutschland, there is no traversing rack provided in connection with the roller track. Motion is transmitted through chains and gears from the motor or handwheel to the traversing pinion which meshes with the two gears bolted to the faces of the traversing rollers, figure 2. The simplicity of this mechanism is very striking, especially for guns of this size. Apparently, it worked satisfactorily, or it would not have been retained in a gun of such value. It is certainly worthy of serious consideration for similar carriages for our own service. An azimuth circle is embedded in the vertical walls of the concrete emplacement about 2 feet from the top, plate 512. An indicator is provided on the rear of the carriage, with a vertical wire quite close to this azimuth circle. The switchboard and seat for the traversing operator are located beside this indicator.

804. Carriage.—The carriages are constructed entirely of structural steel. The side girders are in three main sections, comprising a central section of uniform depth, a top brace for the trunnion support, and a bottom section for the pintle, plate 511. The pintle design is shown in figure 1 of plate 515. It is ball bearing, the balls being about 15 centimeters in diameter. In this case the racer serves as a pintle, having a positive bearing against the base ring for the transmission of the horizontal component of the force of recoil into the foundation.

181768—21——50

PLATE 515


ROLLER TRACK
4'
C. STEEL BASE
6" BALLS
6'
CONCRETE PIT
30'
SECTION OF EMPLACEMENT
BREECH LUG
FOR BRAKE CYL.
PISTON RODS
BEARING AGAINST CYL.
RECUPERATOR CYLINDER
BREECH LUG, SHOWING METHOD GUIDING DURING RECOIL
SHOT TRUCK
LEVERS & LATCH HOLD SHELL ON RIGHT SIDE DURING TRANSPORTATION. WHEN READY TO LOAD IT IS RELEASED AND ROLLED TO OTHER SIDE
POWDER TABLE
CRANK FOR 2 MEN
CHAIN
TRAVERSING GEAR
8" FACE
2.5" FACE
BATT'Y "KAISER WILHELM II", 305mm.
DETAILS

805. Ammunition Supply System.—The general plan of the Battery Kaiser Wilhelm II is shown on plate 516. Storehouses are located on the left of each gun and the main storehouse is 100 meters to the left of the battery. The narrow-gauge line shown extending from the main storehouse, passes through each auxiliary storehouse. A typical plan of one gun and its storehouse is given on plate 511. The double narrow-gauge lines shown passing through the storehouse are the same as those shown on plate 517. These storehouses are of excellent construction and are typical of the design of the storehouses for most of the heavy batteries inspected. The plan for the Battery Deutschland was almost identical. The external plan for the Battery Pommern was slightly different, but the interior arrangement was well nigh the same.

806. Projectiles are transported from the main storehouse to the individual storehouses on narrow-gauge railway trucks. From these trucks they are carried by means of an overhead trolley through openings in the walls into the projectile rooms, where they are stacked two high. Later they are picked up and carried by the same trolley into the corridor just outside the shell room and placed on the shot trucks, figure 4, plate 514. The table of this truck is quite broad and the shell is placed on one side where it is held by two arms until it is to be rammed. The truck is provided with a shelf, presumably for powder. There was no evidence of any scheme of handling the ammunition except by hand. The rammer found beside one of the guns is of such a length as to indicate that the projectile was probably rammed by eight men. The guns are loaded at zero elevation. Another practice shell-ramming tray, plate 517, was found beside one of the emplacements.

807. Emplacement.—The design of the emplacement for these guns is shown on plate 511. It will be observed that all the space about the gun leading to the ammunition storehouse is floored with concrete. In this respect the emplacement differs from that of the Battery Deutschland in which the concrete work did not extend much beyond the vertical walls of the pit. It is not known just why the walls of the pit are higher in front than in the rear. There seems to be no particular reason for it. The depth of the pit to the roller path is 2.4 meters, and the total depth 3.6 meters.

808. Protection.—Each of the four guns of this battery is protected with 6-centimeter flat armor. The guns and carriages were likewise elaborately camouflaged to hide them from the sight of the airmen, but air photographs taken on August 9, 1916, plate 518, indicate that it was perfectly possible to see the emplacements. In spite of all this there was no evidence that any of these guns, carriages, or emplacements had ever been damaged by shell fire from sea or by bombs from airplanes. Some holes were visible some distance

PLATE 516

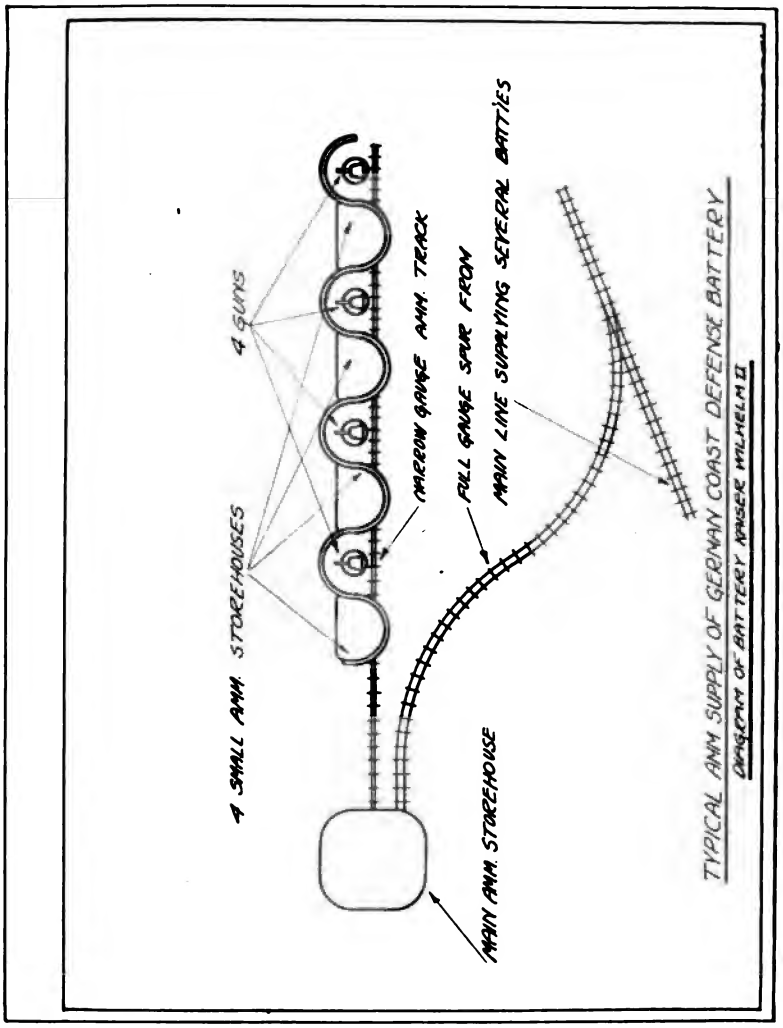
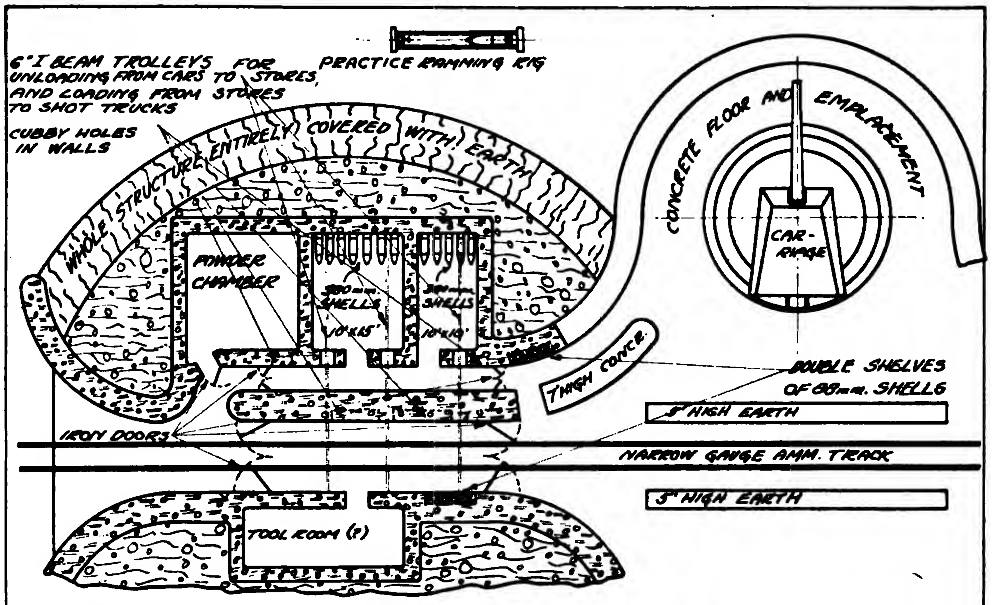

4 GUNS
4 SMALL AMM. STOREHOUSES
NARROW GAUGE AMM. TRACK
FULL GAUGE SPUR FROM
MAIN LINE SUPPLYING SEVERAL BATT'IES
MAIN AMM. STOREHOUSE
TYPICAL AMM SUPPLY OF GERMAN COAST DEFENSE BATTERY
DIAGRAM OF BATTERY KAISER WILHELM II

PLATE 517



TYPICAL AMM. STORES SYSTEM FOR GERMAN COAST DEFENSE GUN.

PLAN OF ONE GUN IN BATT'Y KAISER WILHELM II.
SECTION THRU STOREHOUSE CUT ABOUT 8' ABOVE GROUND.

PLATE 518

AIR PHOTOGRAPH OF THE 305-MM. KAISER WILHELM II BATTERY (TAKEN AUGUST 9, 1916).

in front of the emplacements which may have been made by either bombs or shells. A few similar shell holes were visible some distance to the rear.

28-CENTIMETER GUN RAILWAY MOUNT, BATTERY PREUSSEN.

809. Gun, Cradle, Recoil Mechanism, Elevating Mechanism.—See description of the same for the 28-centimeter Railway Mount, paragraph 367 to 380.

810. Traversing Mechanism.—A description of the details of the mechanism attached to the mount is given under the description of the traversing mechanism for the railway mount. The writer had not had the opportunity to examine the concrete emplacement at the time the description of the railway mount, plate 386, was written. The emplacement shown on plate 519 is typical of the 12 emplacements provided for the three 4-gun batteries along the Belgian coast. There was a steel plate on top of the central base section which was blown off when the Germans were demolishing their fortifications. The standard-gauge track extends a short distance beyond the emplacement, for the forward truck when removed from the mount. It was mentioned under the 28, 24, and 21 centimeter railway mounts that the carriages were so designed that they could all be used on the same emplacement.

811. The auxiliary sections of track that are laid inside the emplacement for the placing of the gun are shown on plate 519. As soon as the gun is in position, the central sections of rail, one piece of which is shown removed, are removed and the base section of the pivot dropped and bolted in place. The carriage is then raised a few inches by means of the jacks shown with the mount, plate 386, and the trucks removed. The short sections of track within the emplacement are likewise removed and the rear of the carriage let down until the traversing rollers rested on the roller path.

812. Carriage.—The details of design of the carriage have been fully described in paragraph 373.

813. Emplacement.—The various details of the emplacement are shown on plates 519 to 521. The two short central sections of rail, figure 1, plate 520, are connected by a steel plate which rests on top of the base for support as the mount passes over. Some curious markings on the vertical wall of the pit are shown on plate 521. The central vertical line is obtained approximately by passing through the center of the emplacement a line perpendicular to the general line of the coast. The distance between the vertical graduations labeled 0–50 and 50–100 is about 2 feet, and the total angular distance covered from the center to the graduation 250 is about 60 degrees. A complete azimuth circle was found painted at the outer edge of the roller track. This circle, however, could not have been

PLATE 519

EMPLACEMENT OF THE 28-CM. RAILWAY BATTERY PREUSSEN.

PLATE 520

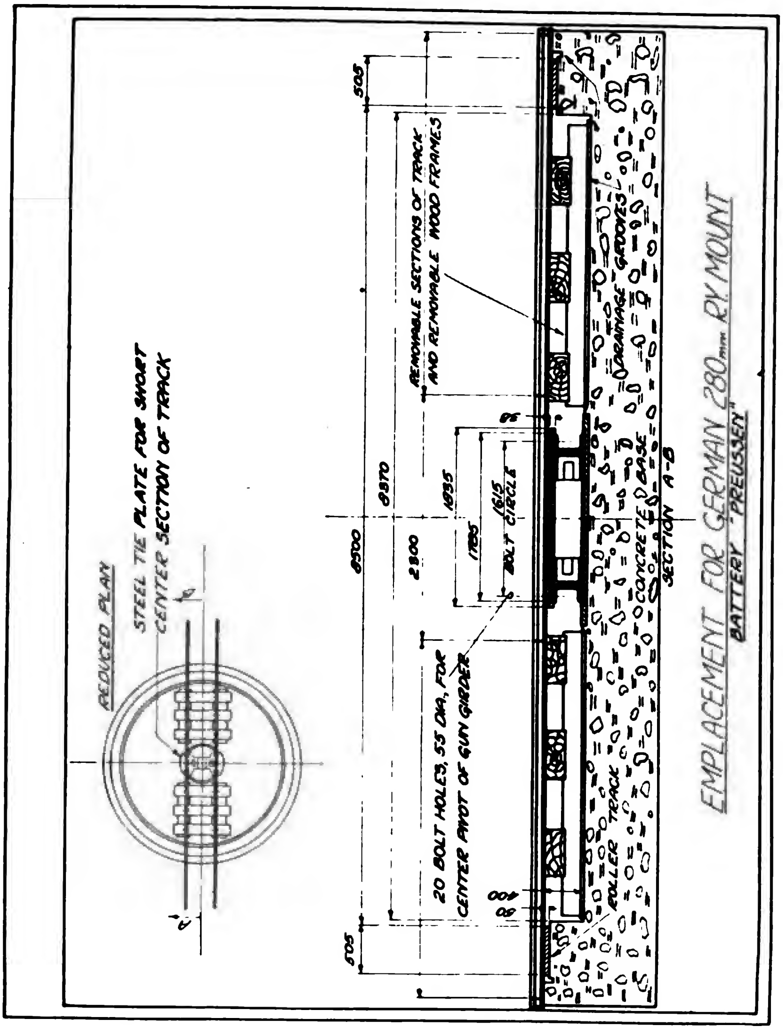
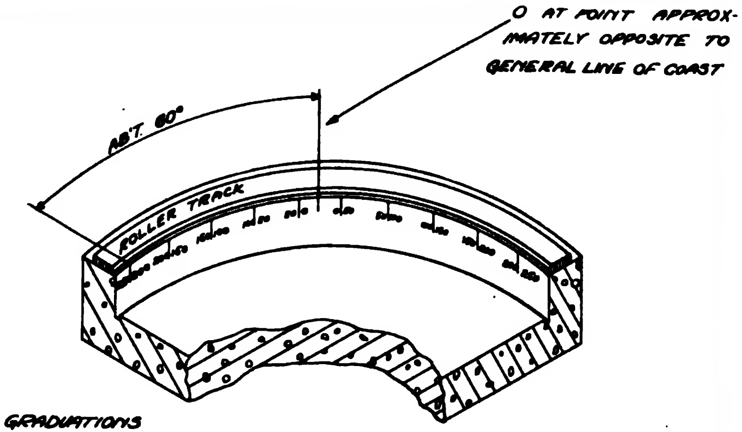

REDUCED PLAN
STEEL TIE PLATE FOR SHORT CENTER SECTION OF TRACK
REMOVABLE SECTIONS OF TRACK AND REMOVABLE WOOD FRAMES
20 BOLT HOLES, 55 DIA, FOR CENTER PIVOT OF GUN GIRDER
505
8500
8970
2300
1835
1785
1615
BOLT CIRCLE
95
400
60
505
DRAINAGE GROOVES
CONCRETE BASE
ROLLER TRACK
SECTION A-B
EMPLACEMENT FOR GERMAN 280mm RY. MOUNT
BATTERY "PREUSSEN"

PLATE 521



NOTE: IDENTICAL GRADUATIONS ON OPPOSITE SIDE OF EMPLACEMENT. NEITHER IS CONTINUED ABOVE 250.

GERMAN 280mm. RY. GUN EMPLACEMENT, "PREUSSEN"
PAINTED GRADUATIONS ON VERTICAL WALLS

used, except for the approximate laying of the gun, since it was not made with sufficient accuracy. It seems more probable that the mount was laid in azimuth from some aiming point.

814. The general location of the emplacements with reference to the main railway line on which the mounts were brought in and likewise with reference to the coast line is shown on plate 522. Two spur lines were run in from the main line. It is not quite clear why this was done; it would obviously have been possible to run short lines to the two guns on the left from the spur line in the center connecting the main line with the two guns on the right of the plate.

815. Ammunition Supply System.—The location of the ammunition storehouses and the narrow-gauge connection with the emplacements is shown on plate 522. In each case the standard-gauge line runs at the rear of the quite simple concrete storage houses which are provided with two doors both at the front and at the rear, plate 523. The powder is kept in the one storehouse and the shells in the other. A double line of 30-centimeter track connects the storehouses with the two emplacements. These narrow-gauge lines connect with turntables just inside the wicker protection. A complete circle of narrow-gauge track is provided about each emplacement, making it possible to supply the shells to the mount in any position. There was no evidence of any scheme of storing the projectiles or powder closer to the mounts than the storehouses. Evidently a sufficient number of shot trucks are provided for these narrow-gauge lines that the shells can be provided directly from the storehouses at the maximum firing rate of the gun. The ammunition storehouses were well camouflaged, plate 522, but in spite of this camouflage air photographs taken in 1918 indicate clearly the position of all of the guns as well as the storehouse.

816. Protection.—The gun crew was protected to a certain extent by the light sheet metal cab on the mount, plate 386. The mounts were likewise well screened with wire and brush, remains of which can be seen on plate 519. In spite of this camouflage air photographs showed quite clearly the positions of the emplacements. There was no evidence of damage from shell fire or air bombs on the emplacements or storehouses. A heavy concrete headquarters shelter with telephone connections from the observation stations in the dunes and telephone connections to the various guns was provided between the pairs of guns. In each case there is a cable through the central pintle base which evidently carries the telephone connections between headquarters and the mount.

28-CENTIMETER GUN, BATTERY TIRPITZ.

817. Gun.—Battery Tirpitz is a four-gun battery and all of the guns are of model 1911. The gun of the four which was examined in detail was model 1911, No. 5. Its weight is 33,875 kilograms.

PLATE 522

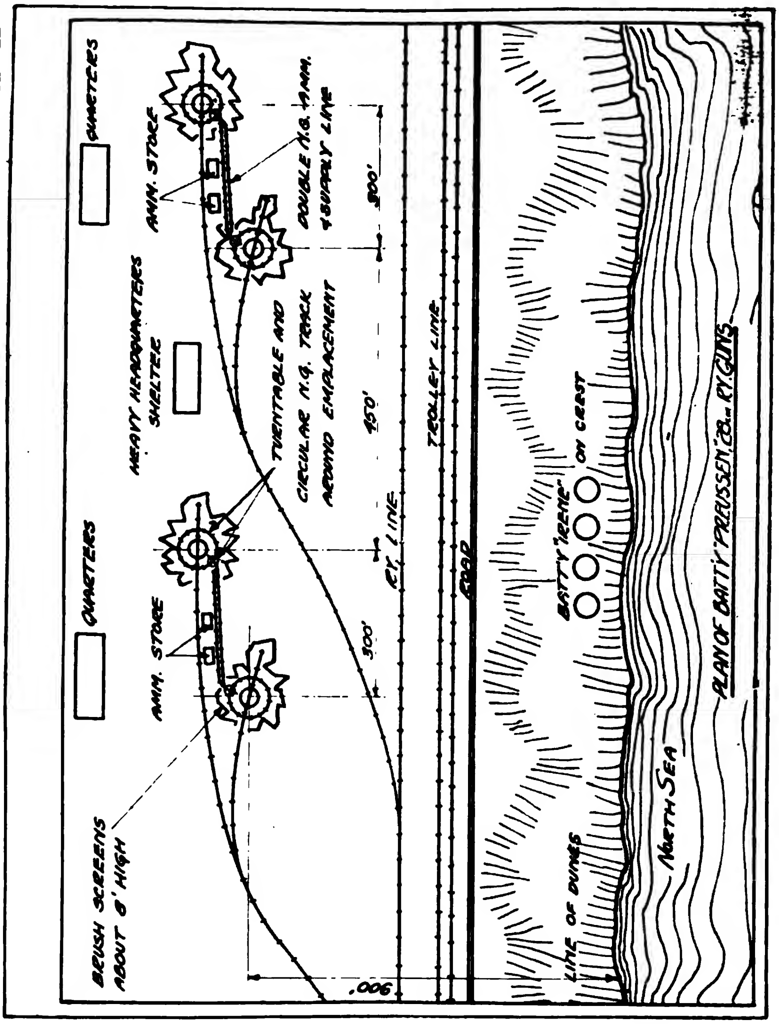

BRUSH SCREENS ABOUT 8' HIGH
AMM. STORE
QUARTERS
AMM. STORE
QUARTERS
HEAVY HEADQUARTERS SHELTER
TURNTABLE AND CIRCULAR N.G. TRACK AROUND EMPLACEMENT
DOUBLE N.G. AMM. & SUPPLY LINE
900'
300'
450'
300'
RY. LINE
TROLLEY LINE
ROAD
BATT'Y "IRENE" ON CREST
LINE OF DUNES
NORTH SEA
PLAN OF BATT'Y "PREUSSEN" 28cm RY. GUNS

PLATE 523

AMMUNITION STOREHOUSE OF THE 28-CM. RAILWAY BATTERY PREUSSEN.

The length of the tube from the face of the breechblock to the muzzle is 11.220 meters, and the over-all length of the gun is 11.950 meters. There are 80 grooves, and the twist of the rifling is to the right 1 centimeter in 10 centimeters. The diameter of the powder chamber is 30 centimeters. The breech is of the usual Krupp sliding wedge type. As with the 38-centimeter gun found on the railway mount, the tube of this gun has lengthened from firing, thereby separating the forward hoop a noticeable distance from the hoop to the rear, plate 524. Apparently, these hoops are not locked to each other. The lower extension of the breech lug, plate 525, is machined to bear against the planed inner surfaces of the lower recuperator cylinders, thereby preventing rotation of the gun. The gun did not show signs of very great wear, both the lands and the grooves being quite sharp.

818. CRADLE.—The cradle is a smooth cylinder, the walls of which are 10 centimeters thick. It is lined with bronze liners about 6 millimeters thick by 1 meter in length, at both the forward and rear ends. The trunnions are located noticeably close to the forward end. The antifriction device is of the rolling wedge type illustrated on plate 511. There were no unusual features in this design, and no sketch has been made.

819. RECOIL MECHANISM.—The recoil mechanism, plate 525, comprises two recoil cylinders located on the top and bottom of the cradle and four recuperator cylinders. The two recoil cylinders are smooth forgings carried in the cast brackets on the top and bottom of the cradle. Their length, not including the buffer, is 1.22 meters, and the length of the buffer is 24 centimeters. The piston rods, 11.5 centimeters in diameter, pass through holes in the extensions of the breech lug. The length of recoil is approximately 76 centimeters. The four recuperator cylinders are placed symmetrically above and below; the upper cylinders are combined spring and air recuperators, while the lower are spring only. A common air line is connected to the valves on the forward ends of the upper two cylinders. It is believed that the air is supplied from bottles since there was no evidence of an air pump about the carriage. Both above and below, two rods connect the extensions of the breech lug with the crossheads attached to the piston rods of the recuperator cylinders. These rods taper from 4 centimeters at the crosshead to 5 centimeters at the breech lug, and are turned down to 4 centimeters through the breech lug. This design strikes one as being close to the limit of safety as it placed these rods, which are not of very great diameter, always under compression.

820. ELEVATING MECHANISM.—The general design of the elevating mechanism is shown on plate 526. It is operated by hand power only and the ratio of the gearing, as indicated, is five turns of the

PLATE 524

28-CM. GUN OF THE BATTERY TIRPITZ.

PLATE 525

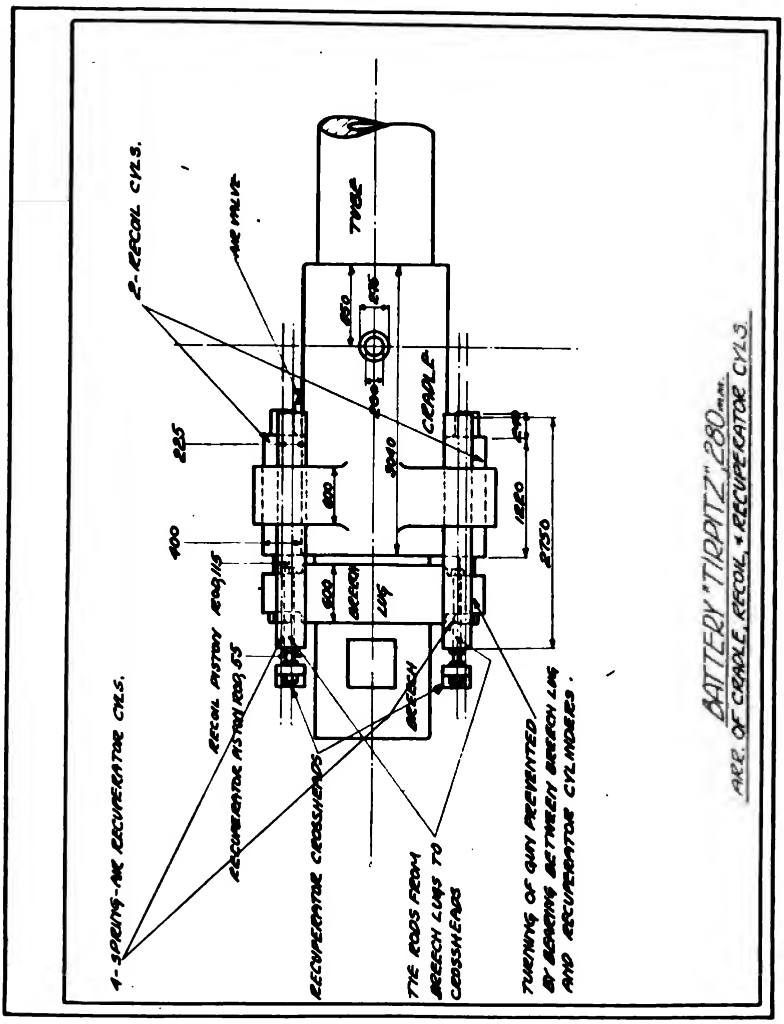
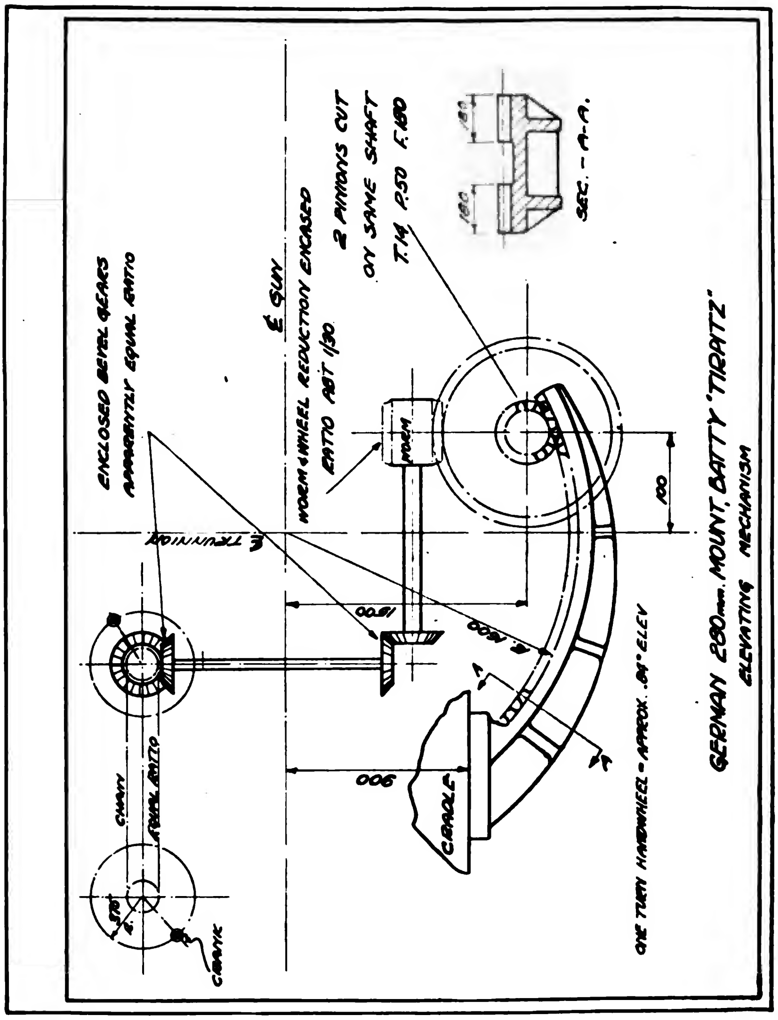

4-SPRING-AIR RECUPERATOR CYLS.
2-RECOIL CYLS.
AIR VALVE
TUBE
CRADLE
BREECH LUG
BREECH
RECOIL PISTON ROD 115
RECUPERATOR PISTON ROD 55
RECUPERATOR CROSSHEADS
TIE RODS FROM BREECH LUGS TO CROSSHEADS
TURNING OF GUN PREVENTED BY BEARING BETWEEN BREECH LUG AND RECUPERATOR CYLINDERS.
225
400
600
3040
1820
2750
BATTERY "TIRPITZ" 280mm.
ARR. OF CRADLE, RECOIL, & RECUPERATOR CYLS.

PLATE 526



181768—21——51

handwheel for four degrees of elevation. The elevating rack is double, although cast in one piece. Identical pinions on the same shaft and of the dimensions shown mesh with these racks. The range of elevation is from zero to 45 degrees.

821. TRAVERSING MECHANISM.—The traversing mechanism is quite similar to that found on the guns of the Battery Kaiser Wilhelm II. Details of this traversing mechanism are shown on plate 527. As with the 305-millimeter battery, there is no traversing rack attached to the roller path. The operation is by hand only from a large handwheel located on the left side of the carriage and about on a level with the roller path. In the case of the 305-millimeter carriages the single pinion meshed with spur gears attached to the face of the two large rollers. In this case, the motion from the large handwheel is transmitted directly to only one of the four rollers on which the rear of the carriage is supported. Although the mechanism was seriously damaged, it was possible to traverse the carriage just far enough to indicate that one man could operate the mechanism without difficulty.

822. CARRIAGE.—It was not possible to secure such a photograph of these mounts as would show satisfactorily the construction of the carriage. In general, the design is not unlike that of the carriages for the 305-millimeter guns. There are two main girders, each of which is in three sections, a central section of uniform depth, a top section for the trunnion support, and a bottom section carrying the pivot. It is made of standard structural plates and angles throughout. The racer is attached to a heavy yoke which is supported by its trunnions in heavy trunnion bearings attached to the carriage. The design of the racer connection with the carriage is not at all unlike that found on the 28, 24, and 21 centimeter railway mounts.

823. EMPLACEMENT.—The emplacement is quite similar to that already described for the 305-millimeter guns. The traversing roller path is practically identical and the general dimensions of the pit are nearly the same. Again there is a raised section of concrete in front of the gun, the purpose of, or necessity for, which is not clearly understood. It is understood that unusual difficulties were encountered in constructing these emplacements, inasmuch as the ground is quite swampy, and it was necessary to drive numerous piles in order that the emplacement might be sufficiently stable.

824. AMMUNITION SUPPLY SYSTEM.—The ammunition supply system for this battery is quite similar to that shown and described for the 305-millimeter gun. The shot trucks are of the same design.

825. PROTECTION.—Each of these four guns is armored with 6-centimeter flat armor. In spite of the camouflage, the remains of which can be seen on plate 524, legible air photographs were secured on August 9, 1916, plate 528. The camouflage is carried on a framework attached to the carriage and rotates with it. Most of the con-

PLATE 527

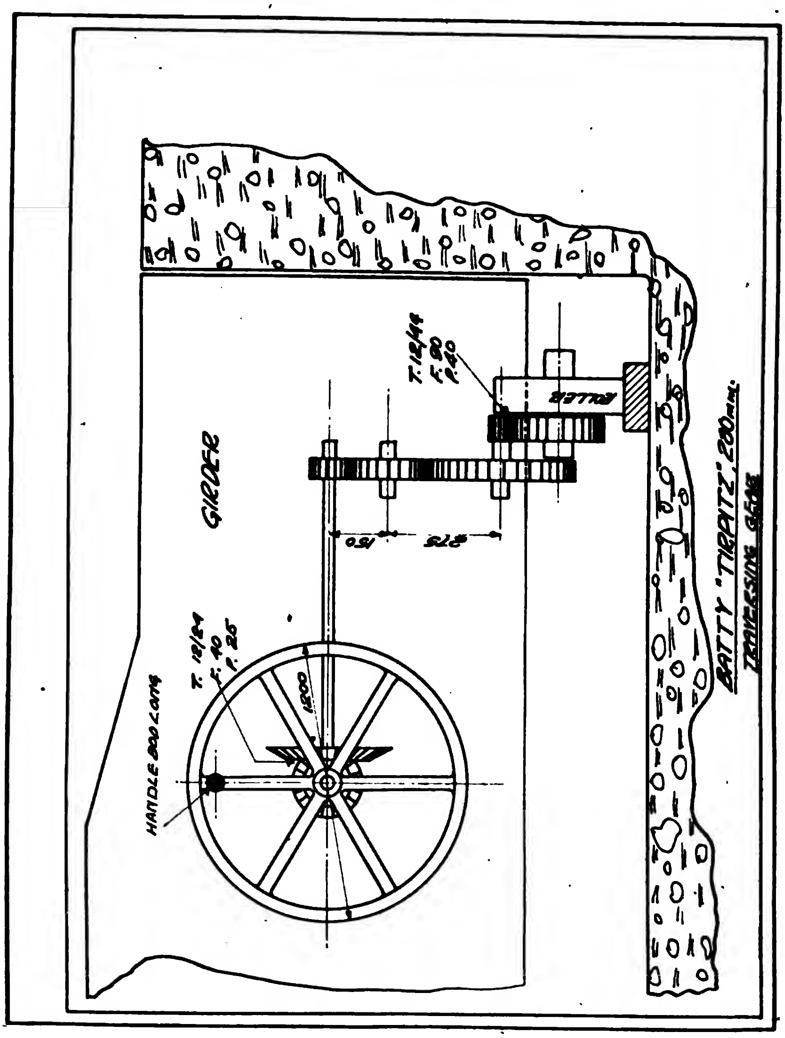

GIRDER
ROLLER
HANDLE 800 LONG
T. 12/44
F. 80
P. 40
T. 12/24
F. 40
P. 25
BATTY "TIRPITZ", 280mm.
TRAVERSING GEAR

PLATE 528

AIR PHOTOGRAPH OF THE 28 CM. BATTERY TIRPITZ (TAKEN AUGUST 9, 1916).

crete work about the guns is completely demolished, but there is no evidence that would indicate to the writer that any of the destruction had been effected by shell fire from the sea. It is certain at least that none of the carriages had been so struck or damaged. There are numerous holes to the front and rear of the batteries that were probably made by air bombs.

28-CENTIMETER MORTAR BATTERY GRODEN.

826. TOP CARRIAGE.—These mortars are supported directly by means of trunnions on a structural steel top carriage of the design shown on plate 529. This carriage was supported on the inclined sides of the main carriage by means of four rollers, two on each side.

827. RECOIL MECHANISM.—The recoil mechanism, which does not show very clearly on plate 529, comprises two recoil cylinders, the pistons of which were attached to the forward ends of the main carriage body; the cylinders are carried in the sides of the top carriage. The length of recoil is estimated as 1 meter, the gun returning to battery by force of gravity. On the front of the main carriage, there are four buffers, each made up of seven pairs of Belleville washers, 15 centimeters in diameter by 5 millimeters in thickness.

828. ELEVATING MECHANISM.—The elevating mechanism comprises a single circular rack bolted to the gun and meshing with a single pinion on a horizontal shaft in the top carriage. The handwheel operating the elevating mechanism is located on the right side of the carriage on a platform rotating with the carriage. On the end of the horizontal shaft in the top carriage, there is a worm wheel meshing with the worm carried on a long shaft parallel to the inclined rails on which the top carriage rolls. The worm is simply keyed to the shaft, moving with the top carriage as it recoils. This is the only elevating mechanism observed in which a slip friction device is provided. This slip friction device provides for the slipping of the worm on the end of the horizontal shaft through the top carriage. It includes two sets of Belleville washers.

829. TRAVERSING MECHANISM.—The traversing mechanism is made up of one rack attached to the base ring, a traversing pinion, vertical shaft, and simple spur gear mechanism leading to the handwheel. There is nothing unusual in the design and from the condition of the carriage, it was impossible to traverse it to learn the ratio of the gearing. The extent of traverse is 360 degrees.

830. CARRIAGE.—It is believed that the carriage is shown in such detail on plate 529 as to make any lengthy description unnecessary. The diameter of the ball path is 3.5 meters, and the balls are about 10 centimeters in diameter. The carriage is constructed throughout of standard structural steel.

831. EMPLACEMENT.—The pit is 6 meters in diameter, and 1.5 meters in depth. In front of each mortar there is a concrete parapet

PLATE 528

28 CM. MORTAR OF THE GERMAN BATTERY GOEBEN.

about 5 meters high, having a slope of about 45 degrees. A part of this parapet is shown at the left foreground of plate 529, and is evidently a continuation of the concrete storehouse which is covered with earth.

832. AMMUNITION SUPPLY SYSTEM.—The ammunition supply system is shown on plate 529. Between the shell table and the road, a narrow gauge line can be seen, which leads to the main storehouse. At the end of the shell table on the concrete floor there are guides to place the shot truck in loading projectiles from the table. It is assumed that the mortars were loaded at zero elevation, although this is not certain. The shot truck is similar in design to those used with the 38-centimeter guns and shown on plate 505. Since the powder charge was not of great weight, it is probable that it was carried in a two-man tray.

833. PROTECTION.—The only protection afforded these mortars has been mentioned under "emplacement." There was no evidence of any camouflaging, although it is assumed that some sort of camouflage was provided. Air photographs taken in 1916 revealed the presence of these mortars, and it is quite certain that no amount of camouflage could effectively conceal them. There is no evidence, however, that any of them had ever been either struck or damaged by shell fire or bombs.

17-CENTIMETER GUN, BATTERY GOEBEN.

834. GUN.—All of the guns of this battery, plate 530, are model 1914, and the gun examined in detail is model 1914, No. 71–L. Its weight is 10,701 kilograms, the length of the tube 6.44 meters, and the total length of the gun is 6.980 meters. There are 52 grooves, and the twist of the rifling is to the right 1 centimeter in 10 centimeters. The diameter of the powder chamber is 19 centimeters and the breech is of the standard Krupp sliding-wedge type.

835. CRADLE.—The cradle is identical in design with the cradle found with the 21-centimeter railway mount. There are two hydraulic buffer cylinders, one on the top and the other directly below the cradle, and each is attached to the cradle by a heavy pin, about which it can rotate in a vertical plane. Four spring cylinders are arranged about the cradle symmetrically, two above and two below. The design of this type of cradle is shown on plate 374. The diameter of the trunnions is 22 centimeters and the length 15 centimeters. The antifriction device is of the design shown for the 15-centimeter guns on plate 535.

836. RECOIL MECHANISM.—The outside diameter of the recoil cylinder, plate 531, is 25 centimeters and the estimated length of recoil 40 centimeters. As noted before, the recuperator cylinders are four in number and they are 1.6 meters in length. There are two columns of springs in each cylinder, the mean diameter of the outside

Plate 530

17 CM. GUN OF THE GERMAN BATTERY GOEBEN.

PLATE 531

CRADLE RECOIL CYLINDERS AND RECUPERATORS OF THE 17 CM. BATTERY GOEBEN.

spring being 17 centimeters, diameter of wire 2.4 centimeters, and the pitch 5 centimeters. The mean diameter of the inside spring is 11 centimeters, the diameter of the wire 1.5 centimeters, and the pitch 3 centimeters. Tension rods connect the crosshead at the front of each spring column with the recoil lug.

837. ELEVATING MECHANISM.—The elevating mechanism includes a circular rack bolted to the side of the gun near the breech. The pinion meshing with this rack is driven by an electric motor carried on the part of the carriage below the floor.

838. TRAVERSING MECHANISM.—A complete circular rack is attached to the base ring. The traversing motor is carried on the section of the top carriage which extends below the deck and connects with the traversing rack through two sets of bevel gears and one spur gear. The entire original gun and turret mechanism, without any modifications, were installed on the concrete emplacement as shown on plate 530.

839. CARRIAGE.—The one detail of the carriage which seems of interest to describe is the traversing ball bearing. A portion of the light shield protecting the bearing has been torn away approximately at the center of the turret and almost above the long-exposed anchor bolt. It was found on removing this shield that the carriage is provided with a double ball path, the diameter of the outer path being 3.2 meters and the inner path 2.8 meters. The balls in the outside bearing are about 5 centimeters in diameter and in the inside bearing 7.5 centimeters.

840. EMPLACEMENT.—These guns, all placed in the shore dunes at Zeebrugge, are easily visible from the sea. The concrete emplacement shown on plate 530 is about level with the top of the dune. A railway line, evidently constructed by the Germans, runs along the top of the dune just in front of the gun. The thickness of the concrete wall at the rear is about 1.5 meters. This wall increased in thickness on the sides to several meters, flaring off to the right and left at the front. There was a door leading into the operating room under the turret just under the two short anchor bolts seen in the center of the picture.

841. AMMUNITION SUPPLY SYSTEM.—Ammunition was supplied to the gun through the door just mentioned in the emplacement and was hoisted by the usual type of electrical turret hoist. Apparently there was no provision for supplying ammunition in any other way.

842. PROTECTION.—All of the guns were protected as shown in plate 530. This turret was made up of 10-centimeter armor.

843. DESTRUCTION.—Apparently the usual scheme of destroying the gun was not employed in these cases. Instead, by some method they detonated a number of projectiles inside the turret and in the operating room below. All but one of the emplacements was de-

stroyed as badly as the one in the plate. In each case the roof of the turret was blown off. The explosions which destroyed the emplacements do not seem to have destroyed the turret mechanism, as one would have expected. In the case of the gun shown there were about half a dozen unexploded projectiles in the turret and twice that number in the operating room below. All of these projectiles were of the design shown on plate 532.

15-CENTIMETER GUN, BATTERY IRENE.

844. GUN.—All of the guns of the Battery Irene, plate 533, are of the model 1900, and the gun inspected is model 1900, No. 478–L. The weight is 4,861 kilograms, the total length 6 meters, and the length of the tube to the face of the breechblock 5.57 meters. The number of grooves is 44 and the twist of the rifling is to the right 1 centimeter in 10 centimeters. The diameter of the powder chamber is 18 centimeters. The breechblock is of the standard Krupp sliding wedge type.

845. CRADLE.—The cradle, which is not unusual in design, is shown on plate 534. The trunnions are provided with an antifriction device of the design shown on plate 535. Two lugs are cast on the bottom of the cradle near the rear to which the recoil piston is attached by means of a pin. Two other lugs are provided to which the spring recuperator cylinders are bolted.

846. RECOIL MECHANISM.—Attention is called to the rather unique design of the recoil mechanism. This is the only case observed in which the cylinder is carried in the breech lug, the piston being attached to the cradle by means of a pin passing through the two lugs just mentioned. The recuperator cylinders are two in number. Two 3-centimeter tension rods connect the breech lug with the crosshead at the forward end of the spring cylinders. These recuperator cylinders are faced off on the inside at the rear to serve as a guide for the breech lug to prevent rotation of the gun.

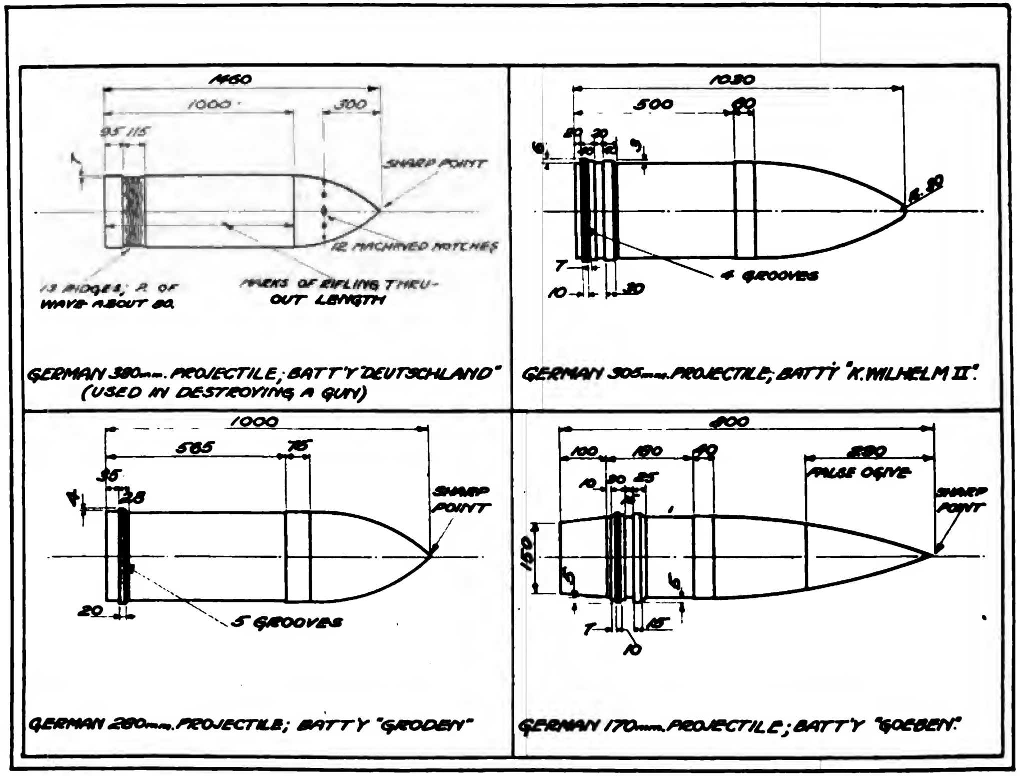
847. ELEVATING MECHANISM, TRAVERSING MECHANISM, CARRIAGE EMPLACEMENT, AMMUNITION SUPPLY SYSTEM, PROTECTION.—There are no features of any of these items that are worthy of description.

848. On the inside of the armor of another carriage of identical design, but of the Battery Kaiserin, near Blankenburg, there was printed firing data, as shown on plate 536.

CONCLUSIONS.

849. GUN.—Most of the guns inspected are about 42 calibers in length, measuring from the face of the breechblock, or about 45 calibers in total length. All guns are provided with the standard Krupp type of sliding wedge breechblock. In all cases, except with the 28 centimeter mortars, which are model 1892, the twist of the rifling is uniform to the right 1 centimeter in 10 centimeters. There

PLATE 532



DESIGN OF THE PROJECTILES USED WITH GERMAN COAST GUNS.

Plate 533

15 CM. GERMAN BATTERY IRENE.

PLATE 532

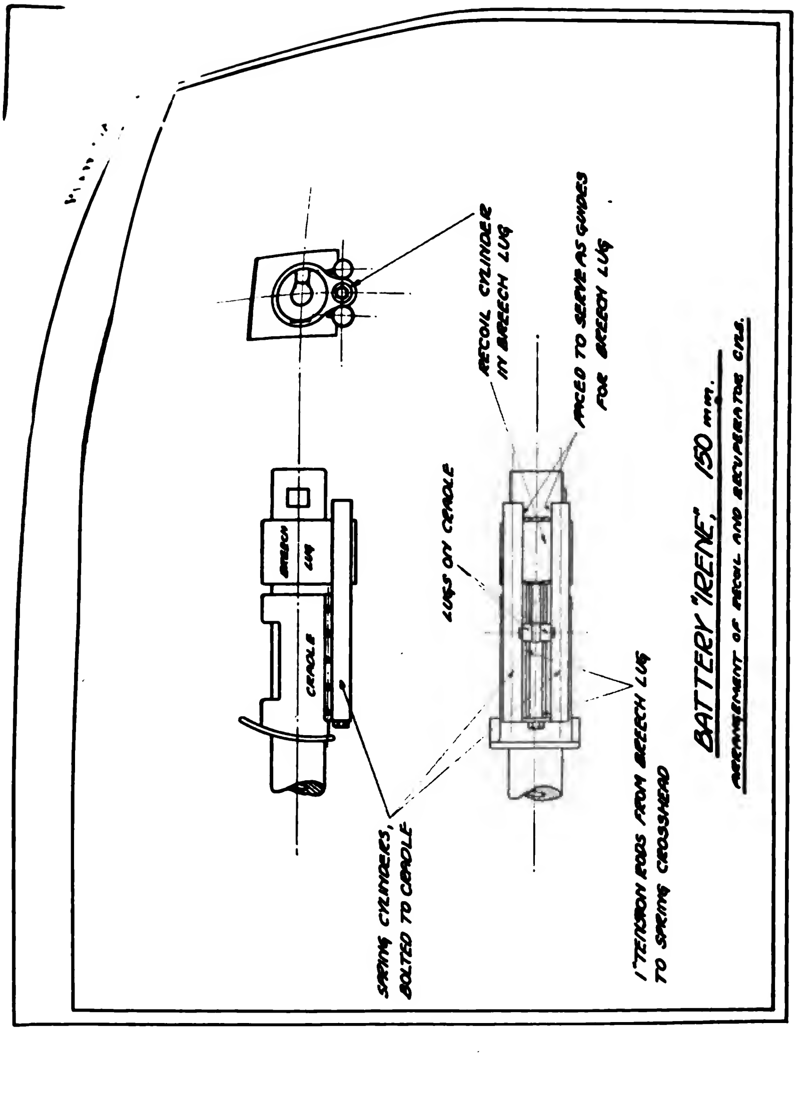
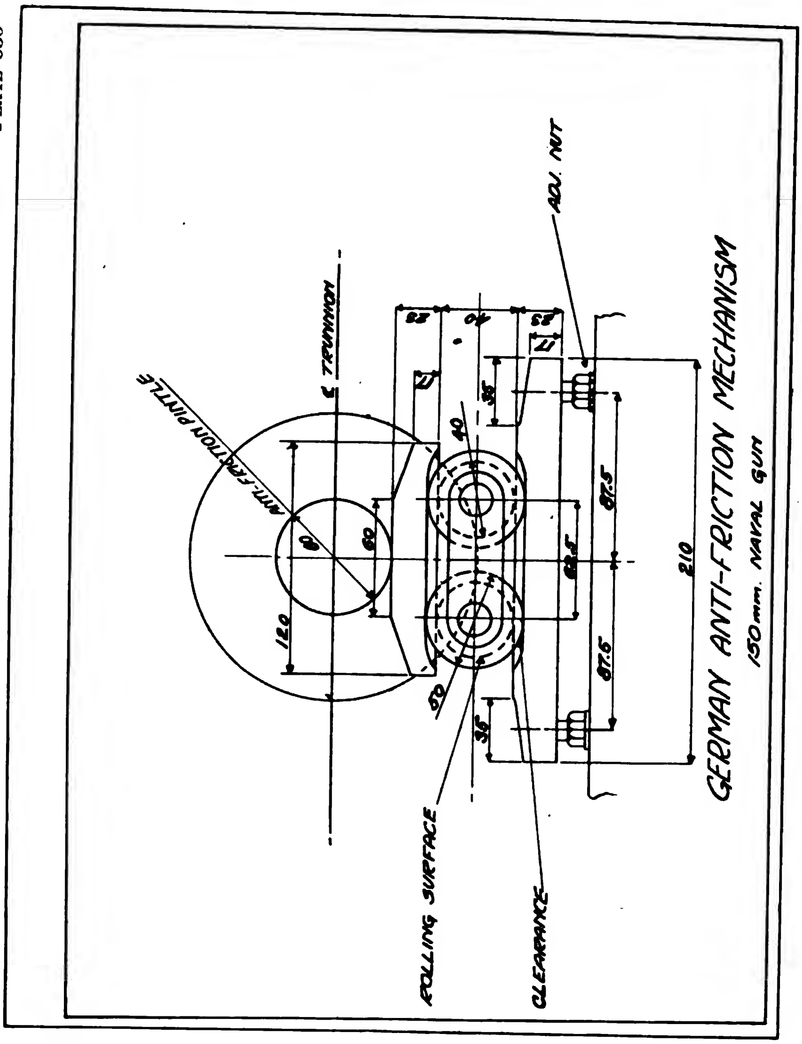
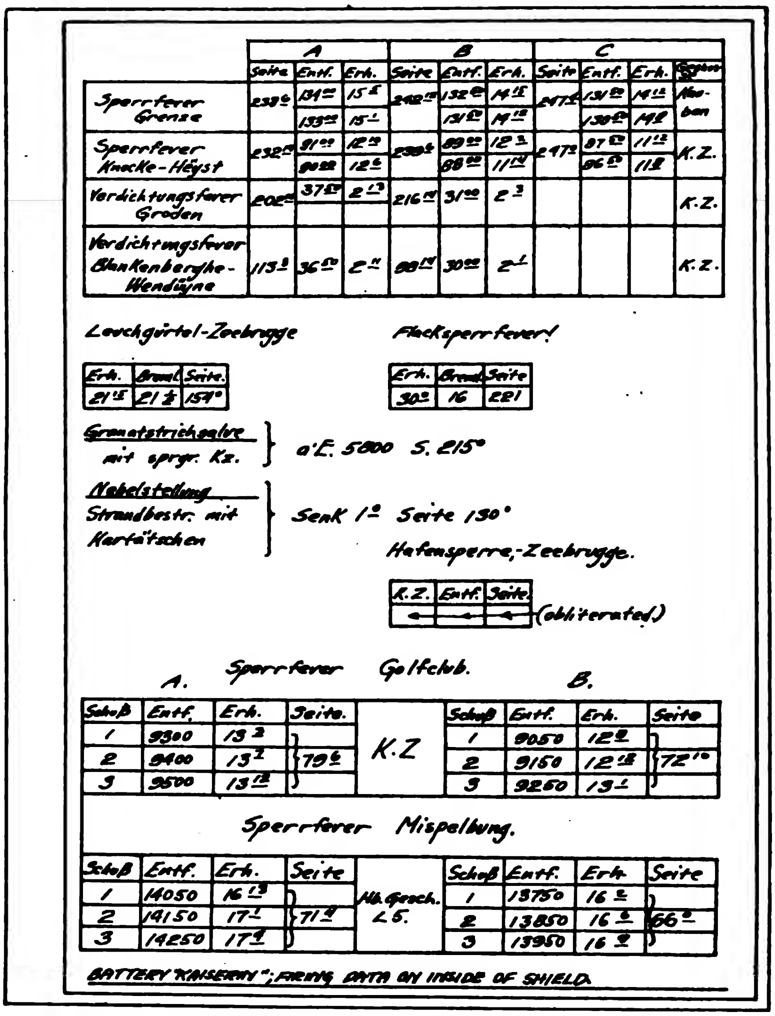

RECOIL CYLINDER IN BREECH LUG
FACED TO SERVE AS GUIDES FOR BREECH LUG
LUGS ON CRADLE
BREECH LUG
CRADLE
SPRING CYLINDERS, BOLTED TO CRADLE
1" TENSION RODS FROM BREECH LUG TO SPRING CROSSHEAD
BATTERY "IRENE," 150 mm.
ARRANGEMENT OF RECOIL AND RECUPERATOR CYLS.

PLATE 535



GERMANY ANTI-FRICTION MECHANISM
150mm. NAVAL GUN

PLATE 536



	A			B			C			
	Seite	Entf.	Erh.	Seite	Entf.	Erh.	Seite	Entf.	Erh.	Geschütz
Sperrfeuer Grenze	238^{5}	131^{00} / 133^{00}	15^{5} / 15^{1}	242^{15}	132^{50} / 131^{50}	14^{15} / 14^{12}	247^{5}	131^{50} / 130^{50}	14^{12} / 14^{8}	Neubau
Sperrfeuer Knocke-Heyst	232^{5}	91^{00} / 90^{00}	12^{10} / 12^{6}	238^{6}	89^{00} / 88^{00}	12^{3} / 11^{14}	247^{2}	87^{50} / 86^{50}	11^{12} / 11^{8}	K.Z.
Verdichtungsfeuer Groden	202^{5}	37^{50}	2^{13}	216^{14}	31^{00}	2^{3}				K.Z.
Verdichtungsfeuer Blankenberghe-Wendüyne	113^{8}	36^{50}	2^{11}	98^{14}	30^{00}	2^{1}				K.Z.

Leuchgürtel-Zeebrugge

Erh.	Brenzl.	Seite.
21^{15}	$21\frac{1}{2}$	157°

Flacksperrfeuer!

Erh.	Brenzl.	Seite
30^{0}	16	221

Granatstrichsalve mit sprgr. Kz. } a'E. 5800 S. 215°

Nebelstellung Strandbestr. mit Kartätschen } Senk 1^{0} Seite 130°

Hafensperre,-Zeebrugge.

K.Z.	Entf.	Seite.

(obliterated)

Sperrfeuer Golfclub.

A.

Schuß	Entf.	Erh.	Seite.
1	9300	13^{3}	
2	9400	13^{7}	79^{6}
3	9500	13^{12}	

K.Z

B.

Schuß	Entf.	Erh.	Seite
1	9050	12^{9}	
2	9150	12^{13}	72^{10}
3	9250	13^{1}	

Sperrfeuer Mispelburg.

Schuß	Entf.	Erh.	Seite
1	14050	16^{13}	
2	14150	17^{1}	71^{9}
3	14250	17^{4}	

Hb. Gesch. ∠5.

Schuß	Entf.	Erh.	Seite
1	13750	16^{2}	
2	13850	16^{6}	66^{0}
3	13950	16^{9}	

BATTERY "KAISERIN"; FIRING DATA ON INSIDE OF SHIELD.

FIRING DATA PAINTED ON THE SHIELDS OF THE 15 CM. GERMAN GUNS.

are no guns older than 1904. Quite a number of the guns are as late as 1916. If the data given in the Bulletin de Renseignement d'Artillerie of January–February, 1919, can be accepted, it is certain that the Germans were securing ranges from these guns at ordinary muzzle velocity far in excess of the ranges that we are securing from our guns. This is probably through the improvement in their projectile design.

850. Cradles.—All cradles constructed may be termed smooth cylinders, and the maximum thickness of the walls is 10 centimeters. The cradles of the larger guns are provided with bronze liners about 6 millimeters thick and 1 meter long, at both forward and rear ends. In all cases, the cradles are provided with the simplest types of brackets for the attaching of the recuperator and recoil cylinders.

851. Provision to Prevent Rotation of the Gun.—All breech lugs are fastened to the gun by the interrupted ring method. All lugs are so shaped as to bear either between two recuperator cylinders or on two sides of a single recuperator cylinder to prevent rotation of the gun. There is no evidence in any case of the use of the spline, typical in American design, for the prevention of rotation of the gun.

852. Hydraulic Buffers.—In most cases, two hydraulic buffers are provided. Apparently, there is no fixed policy of balancing these since, in many cases, the two cylinders are located on the bottom of the cradle. In some cases, the hydraulic cylinders are provided with extensions on the forward end which are evidently counterrecoil buffers. In a number of other cases, no such extensions are visible.

853. Recuperators.—The designers seem to have favored the combined air-spring recuperators for the heavy guns. There is no attempt at balancing them, and the number of cylinders varies from one to four. All of the 380 and 305 millimeter guns are provided with only one recuperator cylinder each. As noted under the heading of "Rotation of gun," in every case the recuperator cylinders are used as guides for the extension of the breech lug to prevent rotation of the gun.

854. Gun Carriage—Traversing Mechanism.—In all cases, the heavy gun carriages are constructed entirely of structural steel, and with the exception of the 28-centimeter mortar carriages, are of the front pintle type. The pintle bearings in all cases are ball bearing and there is only one case of actual provision for direct contact between the racer and base ring for transmission of the horizontal force of recoil into the emplacement. The rear of the carriages is carried on heavy rollers (two to four in number, 10 to 20 centimeters across the face and 0.60 to 1 meter in diameter) running on circular tracks set in the concrete emplacement. In some cases (38-centimeter guns) the traversing pinion meshes with a rack attached to the roller path. In other cases (380 and 305 millimeter guns) the traversing pinion meshes with gears bolted to the face of the rollers

855. Elevating Mechanism.—The variations in the design of the elevating mechanism found on German coast carriages as well as railway carriages is very striking. On the 38-centimeter railway mount found at Brussels, and the 305-millimeter carriages of the Battery Kaiser Wilhelm II, there are double straight racks, but the dimensions and designs differ quite radically. With the 38-centimeter guns of the Batteries Pommern and Deutschland, there are double-telescoping screws. On the Battery Tirpitz there is a double-curved rack attached to the bottom of the cradle. On the Battery Groden, 28-centimeter mortars and the guns of several other batteries, there are single-curved racks attached to the bottom of the cradle. On the Battery Coeben, 17-centimeter guns, circular racks are attached to the sides of the cradles.

856. Ammunition Supply System.—In all cases, the ammunition is conveyed from the storehouses into the gun by hand. The shot trucks are all of extremely simple design, and the projectiles in all cases are rammed by hand.

857. Ammunition Storage.—With all of the heavier batteries, the layout of the ammunition storehouses is as shown on plates 557 and 558. In each case, the storehouses are designed to house projectiles and powder for the main guns as well as ammunition for the anti-aircraft guns provided for the protection of each of the big batteries.

858. Protection.—It is very significant that there is no evidence of a policy of providing heavy protection for these large caliber and valuable guns. Apparently, all of the guns which are provided with the 6-centimeter flat plate armor have been removed from other coast fortifications where they had been previously provided with the same armor. Nearly all of the guns were elaborately camouflaged, but air photographs taken in 1916, 1917, and 1918 show quite clearly the positions of all of the guns, ammunition storehouses, approach tracks, etc.

859. In spite of the lack of protection and the clear evidence of the position of the batteries from air photographs, there is no evidence that any of the guns was ever damaged, or even hit, by shell fire or by bombs from airplanes. It is understood that the coast fortifications were shelled constantly by the heavy guns of the Allies' monitors. The positions of the guns were known, but either the smoke screens that were at once put up by the Germans were unusually effective, or the systems of fire control that were employed were defective. The reasons for the failure of the aviators to obtain any satisfactory results are not certain. They dropped many bombs in the vicinity of the various batteries. It is probable that the accuracy of the antiaircraft guns provided with all of the large batteries was such as to compel the aviators to operate at a very great height.

BIBLIOGRAPHY.

1. "Official Records of the War of the Rebellion," Vol. XI, part 2, pp. 574–576, 610, 615, 664, 717–718; Congressional Library.
2. "Battles and Leaders of the Civil War," Vol. II, pp. 373–374; Congressional Library.
3. "Moblizable Fortifications," Gen. Joseph L. Brent, pp. 57; Congressional Library; published by Williams & Wilkins Co., Baltimore.
4. "War Photographs Taken on the Battlefields During the Civil War of the United States," pp. 95–96; Congressional Library.
5. "Professional Papers, Corps of Engineers, No. 14, Siege Artillery in the Campaign Against Richmond," pp. 23; Office Chief of Engineers; also Library of the War College.
6. "Revue de l'Artillerie," Vol. VII, 1876, pp. 8.
7. "Proceedings of the Institute of Civil Engineers," Nov. 22, 1881.
8. "Minutes of the Proceedings of the Royal Artillery Institute," Vol. XV, 1888.
9. "Revue de l'Artillerie," Vol. LX, 1894, pp. 34.
10. "Revue de l'Artillerie."
11. "Hong Kong Daily Press," June 13, 1900.
12. "Engineer," Sept. 3, 1915; Congressional Library.
13. Ordnance Handbook No. 1783; complete drawings, Office Chief of Ordnance.
14. Gun and gun carriage drawings, Navy Bureau of Ordnance; railway car drawings, Office Chief of Ordnance.
15. Army gun and carriage drawings, Office Chief of Ordnance; Ordnance Handbook No. 1816.
16. Navy gun drawings, Navy Bureau of Ordnance.
17. Army gun and carriage drawings, Office Chief of Ordnance; Navy gun drawings, Navy Bureau of Ordnance.
18. Mortar and carriage drawings, Office Chief of Ordnance.
19. Army gun and carriage drawings, Office Chief of Ordnance; Navy gun drawings, Navy Bureau of Ordnance; Ordnance Handbook No. 2020.
20. Gun and carriage drawings, Office Chief of Ordnance; Ordnance Handbook No. 1985.
21. Howitzer and carriage drawings, Office Chief of Ordnance.
22. Gun and carriage drawings, Office Chief of Ordnance; test firing records, Fort Monroe.
23. Gun and carriage drawings, Navy Bureau of Ordnance; copies of same, Office Chief of Ordnance; Navy Handbook No. 25; five such mounts operated in France under Admiral Plunkett; all mounts now in possession of the Army.
24. Gun and carriage drawings, Navy Bureau of Ordnance; copies of same, Office Chief of Ordnance; both mounts now in possession of Army.
25. Design only, gun drawings, Navy Bureau of Ordnance; copies, Office Chief of Ordnance; carriage drawing, Office Chief of Ordnance.
26. Design only, gun drawings, Navy Bureau of Ordnance; copies, Office Chief of Ordnance; carriage drawings, Office Chief of Ordnance.
27. Howitzer and carriage drawings, Office Chief of Ordnance.

28. Howitzer and carriage drawings, Office Chief of Ordnance.
29. Study only, Preliminary Studies, Calculations, etc., Office Chief of Ordnance.
30. One mount at Aberdeen and one at Fort Monroe; no drawings available; "Super-Heavy Flat Trajectory Guns" (S. S. 769); translation by General Staff, A. E. F., Library, War College; Library, Fort Monroe; A. E. F., G. H. Q., files.
31. One mount at Fort Monroe; no drawings available; "Super-Heavy Flat Trajectory Guns."
32. One mount at Aberdeen; no drawings available; "Super-Heavy Flat Trajectory Guns."
33. No mounts captured by any army; photograph secured from the Krupp Co.; no drawings available; "Super-Heavy Flat Trajectory Guns."
34. One mount and ammunition car captured by British Army, now in England; "Super-Heavy Flat Trajectory Guns."
35. One mount captured by Belgian Army, now in Belgium, probably Antwerp; "Super-Heavy Flat Trajectory Guns."
36. "Manual of the Course for Student Officers," original and translation; Library, Fort Monroe; also A. E. F., G. H. Q. files.
37. See also "Camouflage for Railway Mounts," Journal of the United States Artillery, May, 1919.
38. Original recommendation with reference to shop equipment submitted by Maj. Ralph Plumb, commanding officer of the R. A. R. repair shop, Haussimont, France.
39. War Department Document No. 967.
40. See also Report of Heavy Artillery Board, A. E. F., dated Aug. 16, 1918, on "Equipment for the 12-inch Batignolles Railway Mount," signed H. S. Miller, Lt. Col. C. A. C.; Library, Fort Monroe.
41. A more complete treatment on Clearance Diagrams, with maps and diagrams of all of the principal American railways has been made up by the Railway and Seacoast Carriage Section, Artillery Division of the Ordnance Department; copies on file, Library, Fort Monroe; Office Chief of Coast Artillery.
42. See "Table of United States Army Cannon and Projectiles," Ordnance Pamphlet No. 1676; "Elements of United States Naval Guns," Navy Bureau of Ordnance; "Super-Heavy Flat Trajectory Guns" (German; see reference 30 above.)
43. See also "L'Illustration" (French) for Jan. 4, 1919. See "Genie Civil" (French) for Apr. 20, 1918, for reconstitution and measurement of projectiles. Analyses of projectile made in laboratory of Andre Citroen, Paris. Fragments of projectiles in Museum of Municipal Laboratory in Paris.
44. See also "Journal of the United States Artillery," June, July, August and December, 1919.
45. See also "L'Illustration" (French) for Jan. 4, 1919.

INDEX.

A.

G.

N.

O.

P.

Q.

R.